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Taxonomical structures of Australopithecus : a reanalysis of hominid phylogeny

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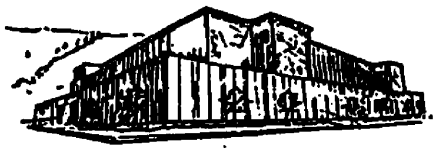

TAXONOMICAL STRUCTURES OF *AUSTRALOPITHECUS*: A REANALYSIS OF HOMINID PHYLOGENY

By

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Taxonomical Structures of Australopithecus: A Reanalysis of Hominid Phylogeny

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Issues concerning taxonomy can render specimens into theoretical obfuscation. This obscurity is especially problematic when the specimens' genetic relationships cannot be established by modern DNA analysis. In light of this problem, anthropology faces grave uncertainty when dealing with reconstructing our species' evolutionary past. Traditional taxonomical influences of both Aristotle (384-322 BCE) and Carolus Linnaeus (1707-1788) have utilized morphological features with latent metaphysical indicators in the determination of species' taxonomical categories. These categories, based on shared characteristics, cannot account for variability or descent found within any species. Establishing human descent becomes more complicated and evident when considering the effects of ecology, culture, and genetics on specified morphological characteristics. Thus, when new hominid discoveries with different or similar morphological characteristics are found, all too often new categories are erroneously created or specimens become taxonomically inclusive due to categorical speciation being confounded within the realm of possible hominid variation. This diversity of categories only serves to augment problems concerning the relationships among members of our species, as well as with our own ancestral descent from fossil hominids. Although cladistical analysis has made great strides in establishing relationships among hominid forms, the goal of this research is to shed light on the taxonomical structure concerning our species' past; particularly focusing on *Australopithecus* and its relationships among other hominid forms.

Since some morphological features are due to variation, it is essential to find the variables that can indicate the genealogical descent of *Homo sapiens sapiens* from our remote hominid past. It is the contention of this author that the taxonomical information required for this task can be derived solely from rudimentary variables of the cranium. This is especially useful when hominid remains are not completely intact. This hypothesis, which will be referred to as the *princeps nitor* hypothesis, will attempt to show that hominid identification and classification can be primarily based upon The Bipedal Index (Universal Hominidae Theorem) and The Cranial Capacity/Bipedality Efficiency Index which incorporate the dynamic relationship of cranial based morphological variables of significant influence.

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Part I

PHILOSOPHICAL AND TAXONOMICAL SYSTEMS

Aristotle and Greek Thought

1.1 In the course for the desire to comprehend the complex nature of human understanding, epistemological quires into both categorizations and essential attributes assigned to an object become necessitated for the proper execution of cognitive functions. Scientific evidence concerning the biological/physiological and mental processes by which our species acquires and processes this information about the external world continues to surpass the philosophical foundation by which both psychology and biology had developed. However great these advancements may become, ancient metaphysical problems remain. The ensuing unique blending of scientific inquiry with philosophical justification will not analyze cognitive processes as such, but articulate both the history and provide a reanalysis using the current methodology used in taxonomical analysis (hominid) substantiated by resolving metaphysical problems surrounding its implementation.

1.1.0 Traditionally, many of these metaphysical problems are due to the residuals of Greek thought; particularly that of Aristotle, which has provided the basis for epistemology and teleological based ontology which has become the structural foundation for Western philosophy and science. In this perspective, Form, function, and *substance* become an integrated relationship that dictates the hierarchical structure and ultimate relationships among various forms of objects. When placed within a taxonomical system, the criteria used become the basis for essentialism. When applied to living genera, problems become less systematic. Yet, when applied to extinct forms, e.g., fossil hominids, plasticity and causality render these systems very problematic. The creators of early taxonomical systems

misunderstood the antiquity and mutability of our species. The implications of this view can easily be seen throughout this thesis.

1.1.1 The Greek philosopher Aristotle (384-322 BCE), the father of biology and taxonomy, created an enduring system of categorization based on his philosophical perspectives in many writings. Reflected in these philosophical writings, Aristotle depicts the construction of categories is based upon the recognition of essential properties as compared to those attributes that are accidental. For Aristotle, both Matter and Form are united, only to be separated and categorized by the objects' substance (ouisa) and the expressed essence (Aristotle 1995a; Lear 1988). Based on causality, ultimately the four causes, the movement from potentiality to actuality combine to produce an ontology-based teleology (Aristotle 1995b). In this manner, epistemology becomes intricately intertwined with both unfolding ontology and teleology. Therefore, in order for scientific knowledge to be achieved, these categories and their related objects must be able to be demonstrated, e.g., logistics of language (Aristotle 1995c; 1995d). For example, when another human is encountered, the Form and Matter are visualized but the substance is unknowingly recognized. This recognition is expressed as an essence term as humanity. In terms of expressions, the logical sequence and categorization are found within the relationship between subject and predicate. Other attributes, e.g., hair color, eye color, height, weight, are accidental, not essential in the determination of the category "man". In the process of actualization from potentiality, these attributes or predicates may change, e.g., hair color, but the subject or substance remains the same (Aristotle 1995e). When transformed into expressive language, scientific knowledge becomes demonstrative and categorization becomes possible. For taxonomical purposes, this ultimately translates into the Great Chain of Being of eternally fixed forms (species).

1.1.2 In terms of our species, Aristotle places the human form within nature but maintains that it is essentially distinct from the rest of the animal kingdom. This is based in the concept of the soul. The soul or *Psyuche*, unlike the theological sense, inhabits or is infused in all living objects (forms). The arrangement of these objects depends upon the natural disposition of the soul. In this manner, our species was seen as unique; possessing all lower souls, e.g., nutritive, sensitive, and vegetative, and the essential and substantial attribute of rationality. Rationality becomes the qualitative difference that makes scientific knowledge possible. The soul and substance are one, **eternally fixed** throughout the duration from potentiality to actuality. When placed among other categories, what emerges is an account that is both geocentric and anthropocentric. Thus, according to Aristotle, the taxonomical hierarchy within the Great Chain of Being is as follows (from lowest to highest): minerals, plants, animals, Man, celestial bodies, and the Unmoved Mover. In this scheme, our species is eternally fixed and at the top of the terrestrial chain (Aristotle 1995e; Birx 1991; Lovejoy 1964). This system would eventually fall victim to theological manipulation. Aristotelian philosophy and sacred scripture would later be infused together by the brilliant mind of Thomas Aquinas (1225-1274). Expressed in Aquinas' *Summa Theologica*, the theological view of the Great Chain of Being would be the basis for both the religious and scientific community until the Age of Enlightenment. The problems concerning taxonomy are clear and certain; for species are neither fixed nor eternal. Our species is one of many species that has and will have inhabited this earth.

The Enlightenment: Darwin and Evolution

1.2 Due to the inherited tension created by the conflicting philosophical foundation of both theology and science, the resulting scientific advancements had grave implications for theology. The ensuing philosophical movements

characterized by both rationalist and empiricist positions (1600-1800), expressed the desire to free science, particularly Newtonian physics, from the domain of theology. Although not all perspectives result in the rejection of a divine being, this questioning and rejecting of ecclesial authority would eventually pave the way for the possibility and acceptance of such heretical views as those represented by Bruno, Corpernicus, Kepler, Galileo, and Darwin. Furthermore, the Age of Reason would provide the basis for the greatest iconoclastic idea that would break the Great Chain of Being; that idea is expressed by the theory of organic evolution (Birx 1988; Dewey 1997; Lukaszek 2002).

1.2.0 Charles Robert Darwin (1809-1882), an English naturalist, correctly determined that 'descent with modification' is by means of natural selection, a mechanism which provided an explanation for the diversity of life on this planet. Darwin, an agnostic (in reality, probably a silent atheist), had interpreted evolution in a strictly materialistic manner. Independent from the constraints of both theology and Scripture, this child of the Enlightenment, Charles Darwin, had correctly determined that organic evolution consists of common descent (ancestry), multiplication of species, gradualism, and natural selection (Darwin 2000; Lukaszek 2002; Mayer 1991). Although Darwin did have a taxonomical system in mind as depicted in his work *On the Origin of Species* (1859), it was his idea concerning the mutability of all species that had the greatest critical impact on the concept of the eternal fixity of our own species; thus, ultimately negated the concepts that had been previously established by Aristotle and continued by the father of modern taxonomy, Carolus Linnaeus (1707-1788). Darwin had provided the revolutionary explanation that removed the barrier that separated our species from the rest of the animal kingdom; as for taxonomical purposes, our species differs only in degree and not in kind from the great apes and from other primates in general (Birx 1988; Darwin 1964, 1998; Gould 1977).

1.2.1 Based on variation and natural selection, Darwin realized the erroneous possibilities when taxonomy is based upon resemblances. In his book *On the Origin of Species* (1859), Darwin stated that "we must not, therefore, in classifying, trust to resemblances in parts of the organization, however important they may be for the welfare of the being in relation to the outer world. Perhaps from this cause it has partly arisen, that almost all naturalists lay the greatest stress on resemblances in organs of high vital or physiological importance. No doubt this view of the classificatory importance of organs which are important is generally, but by no means always true. But their importance for classification, I believe, depends on their greater consistency throughout large groups of species; and this constancy depends on such organs having generally been subjected to less change in the adaptation of the species to their conditions of life" (Darwin 1964, pp.414-415). Any subsequent arrangement of these groups within any given class must be genealogical. Expression in variation of each species or group should reflect such modification from a shared ancestral species. Thus, and perhaps anticipating the methodological use of cladistics, Darwin stated that only characters that express real affinities and not analogical resemblances should be used. In this fashion, Darwin held that embryological characters are of high importance in determining classification (Darwin 1964, pp.426-427). Furthermore, Darwin had given to naturalists his words to practice extreme caution when utilizing morphology; for he knew the hidden implications of causality and ascribing special teleological purposes to physical attributes (Darwin 1964). However, classification in general and our species in particular remained under the taxonomical influence of Linnaeus.

Carolus Linnaeus and Modern Taxonomy

1.3 Carolus Linnaeus (1707-1778), Swedish botanist and taxonomist, created the modern system of classification based on binomial nomenclature. In his major work *Systema naturae* (1735), Linnaeus provided the basis for species

differentiation. Utilizing the binomial nomenclature method, Linnaeus reorganized the taxonomical structure that is still used today: Kingdom, Phylum, Class, Order, Family, Genus, and Species. For example, human classification is as follows: Kingdom, Animalia; Phylum, Chordata; Class, Mammalia; Order, Primate; Family, Hominidea; Genus, *Homo*; Species, *sapiens*. Although not an evolutionist, Linnaeus did reject the fixity of species and accepted hybridization. This understanding of hybridization, along with his natural theology, aided in his creation of a natural ordered system that would ultimately reflect a divine order of the universe. Though this system provided a solid foundation for categorization, pervasive taxonomical errors continued due to a lack of genealogical standardization as suggested later by Darwin. Today, additions to the Linnaean system are regulated by the International Code of Zoological Nomenclature (Birx 1988; Mayr 1991; Meikle & Parker 1994). This classification system, however, does not account for ultimate genealogical relationships as expressed by Darwin. Classification based on shared characteristics (mutual absences) became the normal method in taxonomy.

1.3.0 In order to establish or define an existing group within the Linnaean system, today there are three basic ways of classification: Phenetic systematics, Cladistic systematics, and Evolutionary systematics. In Phenetic systematics, specimens are grouped together by their overall similarity, including the mutual absences of any characteristics. Without any defining universal criteria, this system would, essentially, over-classify and reduce any genealogical relationships into obscurity. Time and phenotypic plasticity makes hominid analysis virtually impossible using this system of analysis. However, cladistic systematics offers a greater advantage. This system classifies and ranks specimens by the expressed apomorphous characteristics, which are ranked by the degree of recency of descent. The third system is evolutionary systematics. Combining both phenetics and cladistics, specimens are classified by (1) branching and (2) defining evolutionary difference

among the branches. This synthetic approach does have its possibilities, as Darwin had proposed, yet the lack of definitive traits (thus far) and their evolutionary importance would not serve critical analysis. In order to fulfill our expressed desire to find our 'lowly origin' as Darwin had stated, cladistics will offer the greatest possibility (Cracraft 1979; Mayr 1985, 1991). However it must be stated that cladistics is not without error, as will be seen; yet the proper variables or apomorphus characteristics could bring scientific inquiry to fruition.

Cladistical Analysis

1.4 The historical depictions concerning taxonomical analysis have proven, thus far, to be nebulous when defining parameters among closely related species. It was with careful analysis that the historical reality of taxonomy illustrates these concerns. Although both time sequence and ecological spatial arrangement can lead to a more significant definition, the metaphysical implications and the selection of arbitrary features can render these characteristics beyond the probabilistic capabilities of science. Therefore, the structural analysis can lead to homoplasy or fallacies of presumption, particularly that of *accident* or *converse accident.* Attributing these *false causes*, e.g., the appearance of erroneously shared morphological features to a taxonomical framework can have serious consequences. Though living species can be categorized by the aid of genetics, scientists who concern themselves with fossil remains are at a serious disadvantage. In this manner, cladistical analysis can offer a greater refinement concerning species placement, e.g., classifying fossil hominids.

1.4.1 Cladistics utilizes diagrams or cladograms in the process of classification. Essentially, the outcome of the cladistical analysis can aid in the interpretation and construction of a species' phylogeny. In the process of cladistical analysis, the basic phylogenic assumption is that some morphological characteristics are retained by the daughter species during the split from the original species, while

other characteristics appear after the split. In this manner, cladistical analysis separates *plesiomorphous* or ancestral characteristics from *apomorphus* or derived characteristics (Mayr 1985; Skelton et al., 1986). However, ending this subsection with previous statements as a definition would be an oversimplification. In terms of the ensuing analysis concerning the remaining portion of Part I, the following criteria for cladistical analysis will be assumed as depicted by Mayr.

1.4.2 According to Mayr, cladistical methodology should follow basic fundamental principles. Of the numerous postulates used, the most important postulates that govern cladistics are depicted by Mayr in the following criteria: "1. that all taxa should be "monophyletic", with this term redefined in a novel way, in conflict with the traditional definition of this term (p.103); 2. that the term phylogenetic be restricted to the branching (cladistic) component of phylogeny (p.100); 3. that the relationship be measured in terms of "recency of common descent", i.e., narrow gerealogically (p.101-103); 4. that "there is only one dimension in phylogeny and that is the time dimension" (Brundin 1966). Consequently, the splitting of phyletic lines (as reconstructed from the joint acquisition of derived characters) is admitted as the only legitimate evidence in the construction of classifications to consider also similarities or the relative amount of ancestral (plesiomorphus) characters would lead to a "syncretistic system" which "robs the combination of any scientific value" (Henning 1966, 77). He quotes with approval Bigelow's (1956) statement: "Classification must be based on one or the other (on "overall resemblance" or "recency of common ancestry" ...), not on both, if philosophical confusion is to be avoided." (Henning, 1.c.) (p.102, p123); 5. that the categorical rank of a taxon is automatically given by the absolute geological age of the stem species, or (in a less rigorous formulation) by the "relative age" of the stem species (p.114). (see also Crowson, p.251 and the disclaimer by Griffiths [1972, 10,16]); 6. that species can be delimited in time by two successive events of speciation (p.109); 7. that the

splitting of lines is always a dichotomy, resulting in the production of two sister groups (p.109); 8. that "homology is usually defined in terms of common origin in time" (Griffiths 1972, 17). (This is simply not true. Except for the ancestor-descendent relationship, the concept of homology is completely independent of this time dimension. No other cladist has made such a claim. Henning himself adopts Remane's (1952) concept of homology); 9. that "basically" all classifications should be horizontal classifications, valid only for a given time period (Henning 1950, 259) and that therefore the same taxon might be given different categorical rank in different geological periods (p.115)" (Mayr 1985, pp.99-100). Though particular characteristics can be seen as either arbitrary or plastic, the previous criteria would minimize any contending problems. With these commonly accepted guidelines for cladistical determination, the scientific inquiry of hominid phylogeny can postulate possible relationships between the species *Homo* (modern) and the array of hominid forms.

Hominid Taxonomy

1.5 As illustrated thus far, taxonomical classification is based on the similarity of morphological traits. When interpreted within a fixed and eternal framework, or within latent religious provisions as seen with Linnaeus, known fossil remains of hominids would be evaluated as being extinct and non-related species. However, when these same specimens are interpreted within an evolutionary framework, these extinct fossil species can become more than mere distant species but a united framework of life that extends to the earliest hominid forms on this planet. Within this unity of life, our species can trace its descent through various fossil forms. For in this relationship, as seen within the manner of classification, our species will continually re-evaluate itself in light of new discoveries and the reanalysis of previous species.

1.5.0 In terms of this theoretical research, this scientific inquiry will be limited to the following species: *A. afarensis*, *A. africanus*, *A. robustus*, *A. boisei*, *H. habilis*, *H. egaster/erectus*, *H. sapiens sapiens*, and *Pan troglodytes*. The decision not to include species *H. neanderthalensis*, *H. rhodesienssis*, *H. rudolfensis*, and any early Holocene sapiens was necessary due to the limitations on this preliminary research; yet the introduction of *Pan troglodytes* would complement the contrast among our species and the Australopithecines. The relationships among these forms, particularly those of *H. habilis* are a point of particular interest. Omitting the living forms, e.g., our species and *Pan troglodytes*, the following is a descriptive analysis of the hominid forms that are included in this research.

1.5.1 *Australopithecus afarensis* (3-5 m .y .a.) – Discovered from Hadar and Laetoli locations, these hominids are one of the oldest known fossil hominids that belong to the Hominidae family that will be used in this analysis. The description will be limited to the morphological characteristics of the cranium and some features of the post-cranium. Thus accordingly, the species possesses a "strong alveolar prognathism with convex clivus; palate shallow, especially anteriorly; dental arcade long, narrow, straight sided; facial skeleton exhibiting large, pillar-like canine juga separated from zygomatic processes by deep hallows large zygomatic processes located above P4/M1 and orientated at right angles to tooth row with inferior margins flared anteriorly and laterally; occipital region characterized by compound temporal/nuchal crest (in larger specimens); concave nuchal plane short anteroposteriorly; large flattened mastoids; shallow mandibular fossae with weak articular eminences placed only partly under the braincase; occipital condyles with strong ventral angulation" (Johanson et al., 1994, p.133). Furthermore, the post-cranium, e.g., pelvic region and lower limbs, indicates that this hominid form was bipedal, regardless of the indications from the upper extremities. The "appearance of capitate; third metacarpal lacking styloid process; phalanges strongly longitudinally curved; foot navicular with cuboideonavicular

facet; deep peroneal grooves on distal fibulae; anterior margin of illium between anterior superior and inferior spines relatively straight; cervical vertebrae with long process; relatively high humerofemoral index compared to humans" (Johanson et al., 1994, p. 134).

1.5.2 *Australopithecus africanus* (1-3 m. y. a.) – Initially discovered at Taung in the Bechuanaland Protectorate, this species was once considered as the missing link between our species and the common ape. Besides possessing small canine teeth and a more forward foramen magnum, the most significant feature was the presence of the lunate and parallel sulci (Dart 1982). With the cranial capacity of 520 cc, the specimen's (the famous "Taung Child") feature has a "glabella that is tolerably pronounced, but any traces of the salient supra-orbital ridges, which are present even in immature living arthropoids, are here entirely absent. Thus the relatively increased glabella-inion measurement is due to brain and not bone. Allowing 4 mm. for bone thickness in the inion region, that measurement in the fossil is 127 mm; i.e., 4 mm. less than the same measurement in an adult chimpanzee in the Anatomy Museum at the University of the Witwatersrand. The orbits are not in any sense detached from the forehead, which rises steadily from their margins in a fashion amazingly human. The intraorbital width is very small (13 mm) and the ethmoids are not blown out laterally as in modern African arthropods. This lack of ethmoidal expansion causes the lacrimal fossae to face posteriorly and to lie relatively far back in the orbits, as in humans. The orbits, instead of being subquadrate as in anthropoids, are almost circular, furnishing an orbital index of 100, which is well in range of human variation (Topinard, "Anthropology"). The malars, zyygomatic arches, maxillae, and mandible all betray a delicate and humanoid character" (Dart 1994, p.56). The forward position of the foramen magnum indicates that this species has a more erect posture than modern anthropoids. The post-cranial evidence for bipedalism, though fragmentary, includes "a short, wide ilium; (2) well-developed sciatic

notch; (3) a well-developed anterior inferior iliac spine; (4) wide sacrum; and (5) a short ischium" (Aiello and Dean 2002, p.451).

1.5.3 *Australopithecus robustus* (1-3 m. y. a.)- Discovered by Broom, the type specimen from Kromdraai was originally called *Paranthropus robustus.* Though classified as an Australopithecine today, this fragmentary cranium possesses many attributes commonly found in *Australopithecus boisei.* According to the description, the recovered partial cranium is larger than the chimpanzees and as large in female gorillas. The occipital condyle is located on the same plane as the external auditory meatus but forward. There is a reduction of prognathism. The palate is short and broad. Similar but lager than human, the premolars have rounded crowns without high developed cusps. Although the canines were absent, it was estimated that their size was small and human in shape. (Broom 1994) Though Broom did not place this specimen within the same categorization of those at Sterkfontein, variations of this robust form exhibit the following cranial features: (1) estimated cranial capacity of 480-530 cc.; (2) sexual dimorphism of overall features; (3) cresting; (4) thin cranial vaults; (5) robust supramastoid area; (6) broader and shorter cranial base with an anterior position of the Foramen magnum; (7) large and deep mandibular fossae (Wolpoff 1999).

1.5.4 *Australopithecus boisei* (1-3 m. y. a.)- Discovered at Olduvia Gorge, Tanzania, by Mary Leakey and interpreted by Louis Leakey, this hominid form was originally called *Zinjanthropus boisei.* This controversy surrounding this taxon was in part due to the many shared characteristics, yet diverging form the Australopithecines and paranthropus. Considered by Leakey as a sub-member of Australopithecines, this species' major cranial characteristics that differ from the australopithecines can be seen as the following: (1) well develoed nuchal crest; (2) the inion is lower; (3) high vault; (5) foramen magnum is less elongated and positioned more horizontal posterior; (6) massive horizontal ridges; (7) mastoids

similar to modern humans; (8) sagittal cresting; (9) large and deep mandibular fossae; (10) short cranial base; (11) relatively flat face or less prognathism with pronounced zygomatic prominence; (12) wide nasal opening at the top and narrow at the bottom (Leakey 1994a; Wolpoff 1999). When compared to *robustus* or other Australopithecus forms, morphological characteristics indicate bipedality.

1.5.5 *Homo habilis* (2.6 m. y. a.)- Interpreted by Louis Leakey, this hominid is considered the earliest form of Homo to date. Besides the association with culture, e.g., Oldowan culture, the type specimen consisted of two (2) parietal bones and associated fragments, mandible, incomplete hand and foot. With the cranial fragmentation, cranial capacity ranged from 590 cc to 700 cc. The most significant features that separate this species from previous hominid forms are the expanded cranial capacity, reduced tooth size, and the morphological construction of the hand (thus, the descriptive taxon name). Of the cranium, the following description was given: (1) parts of the cranium vault, including the occipital and the posterior margin of the foramen magnum; (2) parts of the parietals; (3) left and right temporosphenoid fragments. The occipital bone has slight sagittal curvature that is within the Occipital Saggital Index of *Homo sapiens.* Teeth are small and show mesiodistal elongation and labiolingual narrowing. Recovery of further specimens indicates that this species was bipedal, at least as much bipedality as seen in Australopithecus (Leakey 1994b; Wolpoff 1999).

1.5.6 *Homo erectus* (1.7 m. y. a.)- Discovered and interpreted by Eugene Dubois at Trinil, Java, this species was originally named *Pithcanthropus erectus.* The combination of a molar, cranium, and left femur would place this as an intermediate form between ape and humankind. Overall, Dubois concluded that this species was simian in its characteristics, as seen in the following description: (1) the femur has an increased rounded form of the inner side of the shaft; (2) a round convex popliteal area; and (3) simian-like trochanteric line; (4) the cranial

capacity is 1000 cc.; (5) receding forehead; (6) torus occipitals; (7) pronouncement of frontal bone's orbital (Dubois 1994; 1937). However, discoveries of hominids of similar characteristics would link *Homo erectus* and *Homo egaster.* The relationship between these two forms is now considered as one or more species (Wolpoff 1999).

1.5.7 Within the subsections of Part I, primary texts containing descriptive analysis were used in order to establish the basic descriptive criteria used in taxonomical analysis. It should be noted that taxonomical names and placement in many cases has led to a reevaluation and subsequent renaming and classification. In any manner, classifications of these hominid forms are seldom in agreement. Within the last twenty years, in regarding the scientific inquiry of Australopithecines, there are six phylogenies in contention. Tobias (1980) accounts them as follows: *A. africanus* (including *A. afarensis)* – *H. habilis* (branch) and *A. robustus/boisei* (branch). White, Johanson, and Kimbel (1981) prefer *A. afarensis* - *H. habilis*, then *A. afarensis*- *A. africanus*- *A. robustus/boisei.* Olsen (1981) depicts an unknown form giving rise to two lines: an undiscovered species – *H. africanus (A. africanus)* - *H. habilis.* The other branch leads from the unknown to *Paranthropus (A. afarensis)* - *P. robustus/boisei (A. robustus/boisei).* Leakey (1981) has an unknown with two branches: one leading to an indeterminate *Homo (A. afarensis)* - *H. habilis.* Then the unknown species leads to an indeterminate Australopithecine *(A. afarensis)* – *A. africanus*- *A. robustus/boisei.* Boaz (1983) depicts two branches. One leads to *A. africanus* and *A. afarensis* – *H. habilis.* The other leads to *A. robustus/boisei.* The final depiction, as presented by Skelton, McHenry, and Drawhorn (1986), depicts the relationship as follows: *A. afarensis* – *A. africanus* – *H. habilis* (branch) - *A. robustus/boisei* (branch) (Skelton et al., 1986). In this scientific inquiry, an analysis of the last phylogeny will be under consideration. Subsection 1.6 will give a brief summary of this analysis.

1.6 The analysis preformed by Skelton et al. (1986) derived morphoclines for 69 traits that are accepted as being significant in the determination of hominid phylogeny. From this construct, 12 complexes were created that illustrated the greatest number of shared characteristics, e.g., Complex 1, to the least shared characteristic as seen in Complex 12. The functional independence of each complex entails a sequence of derived characteristics. When cladistically analyzed, the complexes will be reduced to one complex that will then lead to the resulting hominid phylogeny as stated in the latter section of 1.57 in Part I. The complexes are described in the following subsections.

1.6.0 Complex 1, depicting the greatest number of traits, includes 17 traits. The traits are related to size and shape of tooth, cranial base, and posterior part of the skull (for detailed information of traits, consult Skelton et al., 27:1 p.23). The conclusion that was drawn from this complex is that *A. afarensis* is the most primitive and that *A. africanus, A. robustus/boisei,* and *H. habilis* are more closely related to each other than they are to the primitive form *A. Afarensis.*

A. afarensis – {*A. Africanus* / *A. robustus/boisei* / *H. habilis*}

1.6.1 Complex 2 includes 16 traits. These traits relate to tooth, cranial base, and cranial flexation (for detailed information of traits, consult Skelton et al., 27:1 p.24). The indicators still retains the primitive status of *A. afarensis.* Within this complex, a reduction of prognathism becomes a progressive trend. From this complex, *A. afarensis* evolves into *A. Africanus,* which then gives rise to both *A. robustus/boisei,* and *H. habilis.*

A. afarensis – *A. africanus* - {*A. robustus/boisei* / *H. habilis*}

1.6.2 Complex 3 includes 9 traits. These traits are related to tooth and facial regions, including the mandible (for detailed information of traits, consult Skelton et al., 27:1 p.25). Once again, *A. afarensis* retains the primitive status. An intermediate condition is seen in both *A. Africanus* and *H. habilis*. The greatest degree is seen in *A. robustus/ boisei.*

A. afarensis – {*A. africanus* /*H. habilis*} - *A. robustus/ boisei*

1.6.3 Complex 4 includes 8 traits. These traits relate to tooth, facial, and mandible features (for detailed information of traits, consult Skelton et al., 27:1 p.25). This complex contradicts any morphocline seen thus far. This complex has *A. afarensis* giving rise to *H. habilis*, which in turn gives rise to *A. afarcanus,* ending with *A. robustus/ boisei.*

A. afarensis - *H. habilis* - *A. africanus* - *A. robustus/ boisei*

1.6.4 Complex 5 has 5 traits. These traits are, once again, related to tooth, facial, and mandible features (for detailed information of traits, consult Skelton et al., 27:1 p.26). In this complex, heavy mastication seems to be a trend. The result is that both *A. afarensis* and *H. habilis* lead to *A. africanus*, then to *A. robustus/ boisei.*

{*A. afarensis* / *H. habilis*} - *A. africanus* - *A. robustus/ boisei*

1.6.5 Complex 6 has 4 traits. These traits relate to tooth and facial regions (for detailed information of traits, consult Skelton et al., 27:1 p.26). According to this complex, an enlargement of teeth and related masticatory structures contradict all previous morphoclines. From this complex, *H. habilis* is the most primitive. From *habilis*, the next would be *A. afarensis*, then *A. africanus* to *A. robustus/ boisei.*

H. habilis - *A. afarensis* - *A. africanus* - *A. robustus/ boisei*

1.6.6 Complex 7 includes 3 traits. These traits, again, relate to tooth and facial regions (for detailed information of traits, consult Skelton et al., 27:1 p.26). The direction of mastication remains relatively the same. However, the resulting morphocline differs. *A. afarensis* is seen as the most primitive, then *H. habilis,* ending with both *A. africanus* and *A. robustus/boisei.*

A. afarensis - *H. habilis* – {*A. africanus* / *A. robustus/boisei*}

1.6.7 Complex 8 has 2 traits. These traits are unrelated in any obvious function (for detailed information of traits, consult Skelton et al., 27:1 p.27). Form this complex, it was deduced that A. *afarensis* lead to *A. africanus,* then to *A. robustus/boisei,* ending with *H. habilis.*

A. *afarensis* - *A. africanus* - *A. robustus/boisei* - *H. habilis*

1.6.8 Complex 9 has 2 traits. Considering two cranial features (for detailed information of traits, consult Skelton et al., 27:1 p.27), the complex indicates that A. *afarensis* was most primitive, leading to *A. robustus/boisei,* then to both *A. africanus* and *H. habilis.*

A. *afarensis* - *A. robustus/boisei* – {*A. africanus/ H. habilis*}

1.6.9 Complexes 10, 11, and 12 have only 1 trait each. Considering three different traits (for detailed information of traits, consult Skelton et al., 27:1 p.27-28), similarities with other previous complexes can be seen. The results can be seen in the following:

(Complex 10) A. *afarensis* – {*A. africanus/ A. robustus/boisei*} - *H. habilis*

(Complex 11) A. *afarensis* - *H. habilis* - *A. robustus/boisei* - *A. africanus*

(Complex 12) {A. *afarensis/ A. robustus/boisei*} - *A. africanus* - *H. habilis*

1.6.10 The cladograms resulting from these complexes indicate three points of issue, that being an agreement, refinement, or contradiction. Since the rules of non-contradiction must apply and refinement not being an contending issue, the most parsimonious cladogram can be illustrated by complex 1 as depicted in 1.160 of Part I. In this cladogram, the important characteristics of bipedalism, tooth reduction, hypermastication, decrease in prognathism, parabolic upper dental arcade, the reduction of hypermastication and encephalization follows this evolutionary trend (Skelton et al., 1986). This then can be translated into a phylogenic tree.

1.6.11 According to the most parsimonious cladogram, further evidence, e.g., age and location, must be considered. Although environmental factors are an important consideration, the evolutionary trend when considering the evidence leads to the following phylogeny:

A. afarensis – *A. africanus* – *H. habilis* (branch) - *A. robustus/boisei* (branch)

1.6.12 The resulting analysis clearly indicates the problems that arise when trying to establish base character traits used in cladistical analysis. Traits of significance can become obscured by either previous thought or unknown outlying influential factors or extraneous variables. The consequences surrounding the choice and weight of each trait become critical and highly interpretative. Such criticisms as issued by Falk (1988), Kimbel et al. (1986), and Yaroch (1986) denotes the conflict within the basic constituents of any cladistical analysis. The same concern was an issue from Skelton's et al. studies in 1992. Although Skelton et al. (1998) acknowledges the possibility of trait bias, the feasibility regarding derived primitive traits is given support by the scientific community (Tobias 1988). The obscurity of functionality and trait complexes yields a cornucopia of tangible possibilities; yet, there can only be one solution among many plausible depictions. In this regard, the search for universal characteristics of significance should

remain tantamount to that of the Holy Grail. Nevertheless, the resulting phylogeny logically agrees with the evidence portrayed or dictated by the traits selected. This agreement, however, becomes conditional; conditional to the prospects of new evidence spurred by healthy skepticism.

Part II

THE CALL FOR THE REANALYSIS OF HOMINID PHYLOGENY

David Hume and Skepticism

2.1 David Hume (1711-1776), an English philosopher and naturalist, provided a unique and critical perspective in terms of epistemology. In Hume's *Enquires Concerning Human Understanding* (1748), the objects of human reason (derived from both simple and complex perceptions via impressions) are divided into two distinct groups: *Relation of Ideas* and *Matters of Fact* (his italics). The first group, Relation of Ideas, include sciences pertaining to mathematics, e.g., geometry and Algebra. The knowledge depicted by these scientific methods demonstrates both truth and certainty. However, Matters of Fact are based on *experience* (my italics) or a posteriori knowledge. It is Hume's contention that if multifaceted references based upon experience can be postulated, then multiple perspectives reflect the expressed uncertainty and conditional truth of experience. This uncertainty, as with all Matters of Fact, is based in the relation of *Cause and Effect* (his italics). Believing that each event is independent, Hume states that the impressions of contiguity and temporal continuity do not justify causality. Furthermore, inferences of relationships, either based either deductive or inductive logic, cannot be given to any distinct cause between two events. The relationships between objects, temporally, are conjoined within experience. Therefore, as Hume stated in Part II, Sect.VII of *Inquires*, a cause can be defined as *"an object, followed by another, and where all the objects similar to the first are followed by objects similar to the second."* Furthermore, the psychological aspect of experience was stated as *"an object followed by another, and whose appearance always conveys the thought of that other"* (Flew 1989; Hume 1999).

2.1.0 Though this is a basic outline concerning causality, Hume's epistemology had placed stringent epistemological constrictions upon scientific inquiry. Although a liberal interpretation would create a sense of radical skepticism that could render empirically based scientific knowledge as being impossible, Hume's critical assessment into the very nature of scientific epistemology has merit; for this process will expose both unwarranted claims and ill speculation based on evaluations of physical evidence (Sagan 1996). Essentially, as pertaining to this inquiry, this epistemological perspective can be used to distinguish multivariable factors within spacio-temporal reality; even though causality will ultimately remain uncertain. Though not advocating such extreme interpretations of Hume's philosophical intentions, this author will utilize Hume's Fork in order to establish and validate certain Matters of Fact based on Relation of Ideas.

Morphological Features and Uncertainty

2.2 With advancements in both science and technology, Hume would certainly have to modify his philosophical position. Yet Hume's division between the two categories of Matters of fact and Relation of Ideas is justified. Mathematics and experimentation do provide certain truths in their expressions; albeit the interpretations (Matters of Fact) can lead to questions of validity. These causal conditions (as set by Hume) may not pose a problem for some sciences but it does create a difficult chasm for anthropology and similar social sciences. As expressed in many dialogues among anthropological scholars, the inability or rarity of reaching a united consensus illustrates the point given by Hume regarding Matters of Fact. In spite of this reality, the author will proceed with the "spirit" of Hume and apply Hume's Fork to this taxonomical inquiry.

2.2.0 In regards to Hume, anthropology is at a disadvantage. Paleontologists and physical anthropologists, in particular, are faced with both an incomplete fossil record and limited amounts of physical evidence. Through their efforts, many

fossil hominid specimens were recovered and catalogued (as depicted in Part I, subsection 1.5.1-1.5.6.). However, as Hume would interject, the recovery and description of hominids have no bearing on established relationships either between our species and or with other hominid forms. Conversely, when applying Hume' Fork to the listed traits, the underlying genetic factor that manifests itself as a complex may not always be conducive to the apparent similarities of traits. Although Tobias (1988) suggests that we should not disregard plesiomorphic traits (primitive characters), causality between traits that is reflected in the fossil record becomes impossible to establish.

2.2.1 Furthermore, environmental factors, random mutations, and the speculated *Probable Mutation Effect* (PME) can affect various craniofacial and dental characteristics (Brace 2000; Molnar 2002; Lieberman 1997). When applying Hume's Fork to the fossil record, the connectivity between traits becomes suspect, especially when considering the plasticity of traits and the possibility of parallel evolution. The metaphysical point concerning traits becomes evident. The process of listing similarities and differences of measured traits does yield quantitative data about qualitative objects. However, only a few traits exhibit distinguishing features of its totality; and thus have comparative powers of capabilities (Lieberman 1995). When taken without the conceptualization of time and descent, it is the utilization of this capability that provides the strength and limitation (Skelton et al., 1998) for the cladistical analysis as exemplified by Skelton et al. in Part I, subsection 1.6. This preceding subsection was intended by the author not to detract or dismiss the tremendous contributions made in regards thereof; rather, it is to set a standard for this inquiry by which a healthy amount of skepticism can be satisfied.

2.3 Though Hume's skepticism had illustrated the frailties concerning the nature of this inquiry, acute observations within an evolutionary framework can provide the possibilities for a morphologically universal standard by which hominidae cladistical relationships and phylogenies can be postulated. Traits, complexes, and duplexes have all been used before. If these processes are susceptible to unknown influences, then there must be characters by which key essential features (or traits) can be utilized for morphological evaluation. The key, should it exist, will be seen during embryonic development as Darwin had suggested.

2.3.0 Though the human skull (primate) is comprised of 22 bones, 8 cranium and 14 facial bones, the functional morphology of the occipital bone is an integral part in the developmental process of locomotion; essentially serving as a base support for the developed(ing) brain and the complex array of bone, joints, and ligaments of the spinal column and lower extremities. When taking Darwin's words of wisdom into a theoretical accounting in taxonomy, the cranial base becomes a cogent point of speculation. Utilizing embryology, it is known that by the seventh week of fetal development, the basicranium emerges from the mesoblast or 'investing mass of Rathke' to consisting of parachordal cartilages that form the basilar plate and prechordal cartilages that form the ethmoid plate. Developed *in utero*, this future occipital bone would provide both structural support for the notochord/vertebral column and developing brain and the foundational structure by which the chorndrocranioum and dermatocranium that integrate via intramembranous ossification. Upon birth, the occipital bone consists of four parts: one tabular (composition that varies from one to eight nuclei); 2 condylar; and one basilar. These four parts are conjoined and ossified as one piece by the sixth year of age. Furthermore, the cranial base region is also known to be the first region to reach adult size and provides both a structural

base for the expanding cranium and foramina to neural connection to the facial region and the post-cranium. Though a degree of angulation is experienced during maturation (10 degrees in apes and humans), the morphological features of the cranial base will remain relatively identical (Dean 1988; Degraaff 1986; Gray 1995; Lieberman 2000). This developmental process suggests that the cranial base would hold the solution to the problem of a universal standard by which to speculate on relationships among species. Therefore, the Princeps Nitor hypothesis states the following: morphological features of the cranial base, in conjunction with set point variables, can be utilized for cladistical and phylogenic purposes. This purely theoretical formulation can then be applied to applicable specimens.

Part III

MATERIALS AND METHODS

Data Collection

3.1 Specimens- The selection (and expansion) of species used for this inquiry was primarily based on species used by Skelton et al. (1986). As stated in Part I, subsection 1.5, eight specimens were used in acquiring data for this analysis (see Table 1). Though original fossil material was not available, the replicas that were used are to scale and of museum quality.

Table 1 - Species

SPECIES
Australopithecus afarensis (AL-288)
Australopithecus africanus (STS5)
Australopithecus boisei (KNM ER 406)
Australopithecus robustus (SK-48)
Homo habilis (KNM ER 1813)
Homo egaster (KNM ER 3733)
Homo sapiens (Modern)
Pan troglodytes (Modern)

When examining the eight specimens, the preservation of cranial base's morphology and reconstruction became an issue. Using the criterion established in Part II; the governing epistemology would relegate these specimens and reduce the effectiveness of this inquiry. Given the quality of hominid evidence, liberal epistemological consideration must be given; albeit the condition of specimens will have an overall restriction on evaluation. Therefore, special notations should be stated to address these concerns. The specimen *Australopithecus afarensis* (AL-288), a.k.a. Lucy, is based on the

reconstruction by White. The original cranial fragments would be insufficient to make an assessment. Of the eight specimens, the cranial base of *Australopithecus robustus* (SK-48) and *Homo habilis* (KNM ER 1813) pose varying problems. The specimen *Australopithecus robustus* (SK-48) is distorted, thus rendering the precision of the morphology ineffective. For the purpose of this inquiry, the affinity between *Australopithecus robustus* (SK-48) and *Australopithecus boisei* (KNM ER 406) will retain same values and other variables will be used by previously collected data. In the specimen *Homo habilis* (KNM ER 1813), fragments of the cranial base is missing. Therefore, a degree of symmetry will be assumed in regarding its complete morphological structure.

3.1.0 Regarding sample size, the utilization of single representative or archetype is taken in consideration. However, this restriction has no bearing on universal characteristics set forth in Part II, subsection 2.3; whereby morphological characteristics deemed universal would express uniformity and nullify such concerns. Nevertheless, the issues set forth in this subsection are valid and accurate concerns about posing limitations. Reconstruction and data assumptions can pose serious problems; however, a degree of confidence in previously extrapolated information becomes necessary.

Variables and Terms

3.2 - The variables used for this inquiry are taken from the cranium. Considering the multitude of possible variables, the twenty-one variables are postulated as being significant in three categories: cranial capacity, bipedality, and prognathism (see Table 2). Of the twenty variables, the variables dealing with the size and position of the foramen magnum in relation to other significant variables are a point of scientific inquiry. The remaining variables

were reduced to basic *pivotal* characteristics that other features become dependent upon.

Table 2 – Variables

Variable	Abbreviation
Body Weight (g)	Bodwt
Brain Weight (mg)	Brainwt
Foramen Magnum Length (mm)	FML
Foramen Magnum Breadth (mm)	FMB
Mandibular Fossa to Basion (mm)	MFB
Opisthion to Opisthocranion (mm)	Opopran
Hormion to Basion (mm)	HorBas
Nasal Breadth (mm)	NasB
Nasal Height (mm)	NasH
Occipital Condyle Length (mm)	OcConL
Occipital Condyle Breadth (mm)	OcConB
Cranial Capacity (CM3)	CranCap
Saggital Crest	SagCrest
External Cranial Base Flexation	EBF
Depth of Mandibular Fossa	MFD
Foramen to Bi-tympanic	FmBiTL
Inclination of Foramen Magnum	FmInc
Inclination of Nuchal Plane	InclNuc
O-M Sinus in Height Frequency	OMSin
Species	Species

As depicted in Table 2, the variables can be divided into three scales of measurements: nominal, scale and ordinal. The nine of the twelve scaled measurements were taken by the author using specimens in Table 1 of Part III, subsection 3.1. The three other scaled measures were taken from Aiello and Dean (2002). The eight ordinal scaled variables were taken from Strait et al. (1997). The remaining variable consists of nominally scaled information.

3.2.0 The nine scaled measurements of each specimen were taken five different times and the average listed. Figure 1 depicts four measurements taken for the

variables pertaining to the occipital condyles (breadth and height) and the foramen magnum (breadth and height). Figure 2 depicts three measurements: mandibular fossa to basion, hormion to basion, and opisthion to opisthocranion. The remaining two variables are depicted in Figure 3 pertain to the nasal measurements of breadth and height. The averages of these measurements were calculated and compiled in Table 4 of subsection 3.21 of Part III.

Figure 1

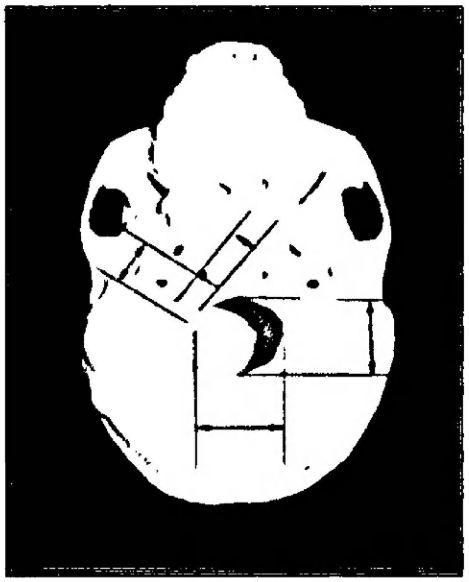
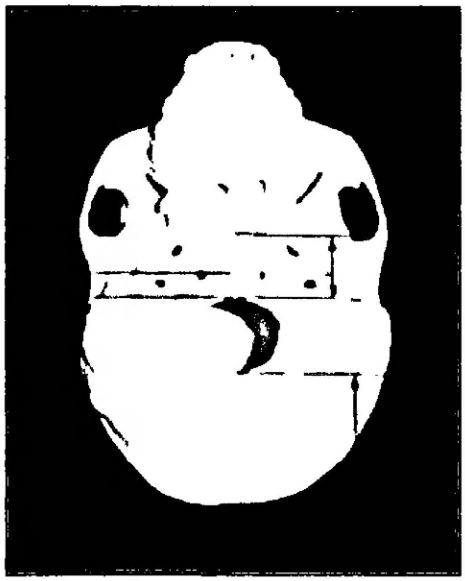
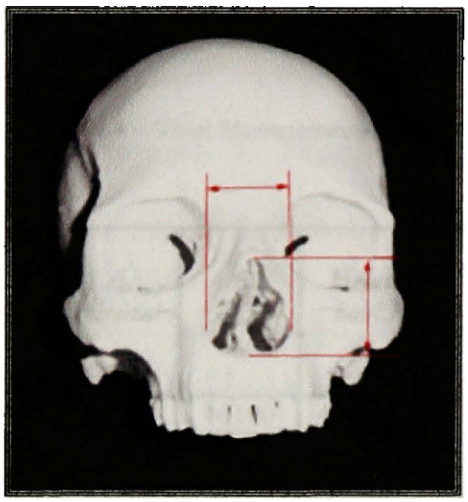


Figure 2



Inferior View Measurements

Figure 3



Frontal View Measurements

Ordinal variables consist of measurements that are placed within constructed categories. The problems relating to this method becomes obvious; however, the criteria governing the defining categorical limits are based on scientific consensus. For the purpose of this inquiry, the categorical limits taken from Strait et al. 1997 will be accepted and reflected in Table 3 listed below.

Table 3 – Ordinal Variables

Depth of mandibular fossa: **(0)** shallow (<15%); **(1)** variable (shallow/intermediate); **(2)** Intermediate (15-25%); **(3)** Deep (>25%).
External Base Flexation : **(0)** flat; **(1)** moderate; **(2)** flexed.
Inclination of Foramen magnum: **(0)** strongly inclined (posterior); **(1)** Roughly horizontal; **(2)** Strongly inclined (anterior).
Inclination of nuchal plane: **(0)** steeply inclined; **(1)** intermediate; **(2)** weakly inclined.
Foramen magnum/bi-tympanic : **(0)** well posterior; **(1)** at bi-tympanic line; **(2)** variable; **(3)** well anterior

3.2.1 From the variables listed in Table 2 in Subsection 3.2 of this part, the resulting measurements are compiled into the following table. This table reflects the species and the variables used in the analysis.

Table 4 – Total Measurements

Variable	*A. afarensis*	*A africanus*	*A. robustus*	*A. boisei*	*Homo hablis*	*Homo egaster/ erectus*	*Homo sapiens*	*Pan*
Bodwt	50600	45500	47700	46100	405000	58600	44000	36350
Brainwt	415000	442000	530000	515000	631000	826000	1250000	410300
FML	26.97	25.20	32.88	32.88	30.14	28.11	34.20	28.00
FMB	21.71	22.81	31.66	31.66	28.38	27.80	32.49	26.25
MFB	16.61	8.72	8.12	8.12	6.75	6.65	13.33	15.77
Opopran	32.69	44.26	39.55	39.55	38.05	50.57	48.29	21.92
HorBas	24.82	28.86	27.45	27.45	15.02	25.51	26.97	36.99
NasB	20.33	23.75	29.55	29.55	20.33	30.99	25.62	31.32
NasH	21.41	25.83	25.03	25.03	26.02	27.43	30.22	30.95
OcConL	18.66	15.31	20.16	20.16	13.36	14.19	21.89	19.46
OcConB	7.68	7.38	8.84	8.84	8.14	7.35	12.36	10.84
CranCap	433	445.28	480.00	480.00	654.00	613.97	1201.00	400
SagCrest	0	0	0	0	0	1	1	1
EBF	1	1	2	2	2	2	2	2
MFD	0	2	2	2	2	1	3	0
FmBiTL	1	1	3	3	2	1	1	0
FmInc	1	0	1	1	1	2	1	0
InclNuc	1	2	2	2	2	2	2	0
OMSin	2	1	2	2	0	0	1	0

From a preliminary evaluation, the morphological characteristics are, in themselves, very misleading. As indicated by Sherwood Washburn, the developing bone structures of the cranium are directly influenced by muscle and nerves; thus rendering some morphological characteristics as being ineffective traits for cladistical purposes (De Vore 1992; Washburn 1942; 1983). Given the status of the cranial base as depicted in Part II, subsection 2.3 and the work established by Washburn, it is speculated by the author that

the morphological characteristics of the foramen magnum in relation to other variables listed holds the key to the elusive mystery. Prior attention was given to the existing relationship between the foramen magnum and other morphological characteristics (Dean 1988; Luboga 1990; Schaefer 1999). However, these inquiries proved to be less than successful in establishing relationships and a criterion for taxonomical purposes. In spite of these attempts, the author's speculation remains firm. In order to confirm this speculation as set forth in Part II, subsection 2.2, this Matter of Fact must be grounded and confirmed by the Relation of Ideas supported by statistical analysis.

Significant Findings

3.3 With the information in Table 4, the variables were subjected to statistical analysis using SPSS, version 12.0. A bivariate correlation yield the following Pearson's correlations with a two-tailed test of significance. Appendix A lists the correlations among all the variables. Upon the initial evaluation of the existing correlations set forth in Appendix A, significant values, e.g., moderate/high (whereas r value is greater than .5), confirms the correlative relationship that was speculated. Using the criterion set forth by the hypothesis in Part II, subsection 2.3, the pattern of development that emerges what was originally postulated about the cranial base. The variables both the foramen magnum length and breadth have a reciprocating correlation with the occipital condyles ($r = .6$, $r = .593$ and $r = .436$, $r = .553$ respectively); mandibular fossa to basion has an inverse correlation with the opisthion to opisthocranion ($r = -.597$) and the foramen magnum to bi-tympanic line ($r = -.608$). Furthermore, there exists a high significant negative correlation with the inclination of the nuchal plane ($r = -.782$ with .022 significance); cranial capacity has a high significant correlation with brain weight ($r = .966$ with 0 significance) and high

correlation with opisthion to opisthocranion (r =.552), foramen magnum length (r = .577) and breadth (r = .536), and occipital condyle breadth (r = .632).

3.3.0 Perhaps influenced by natural phases occurring during fetal development, the correlative values of the variable have confirmed previous speculation concerning the cranial base and its influence on proportional development. Both the opisthion to opisthocranion variable and both foramen magnum and occipital condyle breadth variables have correlative values to brain weight ($r > .6$, $r > .5$, $r > .5$ respectively); whereas opisthion to opisthocranion and foramen magnum (indirectly via nasal) has a correlative value with cranial capacity. Initially, it became surprising when finding the counter-intuitiveness associated between the low correlation between the opisthion to opisthocranion variable and either variable pertaining to the foramen magnum. Aside from cranial capacity, among these various factors, body weight and brain weight appears to be correlative (if not proportional) to opisthion to opisthocranion and the inclination of the foramen magnum. This appears to be correlative with the suggestive method in determining the extent of both brain and body weight of extinct hominid forms (McHenry 1975). This is probable due to muscle attachments and other bipedal features as indicated by Washburn's experiments as stated in Part III, subsection 3.21.

3.3.1 Though the speculated relationship among the variables does pose a logical progression when considered from an embryonic/fetal developmental perspective, the correlative values do not substantiate either universals or what particular variables should be excluded from the analysis. To emphasize the variables relationships, a factor analysis was preformed on all variables included in Table 5. Using SPSS version 12.0, a principle component analysis with rotation (Varimax with Kaiser normalization) produced some interesting

results. As depicted in Table 5, the total variance explained reached 57.6 percent at the third component. What become even more interesting are the rotated components themselves. This is depicted in Table 6.

Table 5 Initial Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.125	34.027	34.027	6.125	34.027	34.027	3.583	19.907	19.907
2	5.040	27.998	62.025	5.040	27.998	62.025	3.403	18.906	38.812
3	2.463	13.683	75.708	2.463	13.683	75.708	3.388	18.823	**57.635**
4	1.900	10.556	86.264	1.900	10.556	86.264	2.711	15.061	72.696
5	1.245	6.918	93.182	1.245	6.918	93.182	2.608	14.488	87.184
6	1.020	5.667	98.849	1.020	5.667	98.849	2.100	11.665	98.849

Table 6 Initial Rotated Component Matrix(a)

	Component					
	1	2	3	4	5	6
Zscore: Body Weight (g)	.197	-.197	-.021	.070	.949	-.077
Zscore: Brain Weight (mg)	.257	.236	**.909**	.052	.203	.079
Zscore: Foramen Magnum Length (mm)	.330	**.783**	.275	-.068	.005	.445
Zscore: Foramen Magnum Breadth (mm)	.418	**.823**	.261	.162	.011	.228
Zscore: Mandibular Fossa/Basion (mm)	**-.708**	-.306	.196	-.026	-.202	.567
Zscore: Opisthion/Opisthocranion (mm)	**.730**	-.075	.440	.010	.493	-.156
Zscore: Hormion/Basion (mm)	-.234	-.221	-.134	.785	-.244	.451
Zscore: Nasal Breadth (mm)	-.101	.275	-.031	.917	.162	.041
Zscore: Nasal Height (mm)	.118	.410	.359	.628	-.443	.025

Zscore: Occipital Condyle Length (mm)	-.050	.230	.109	.163	-.135	.942
Zscore: Occipital Condyle Breadth (mm)	-.148	.350	**.590**	.247	-.433	.504
Zscore: Cranial Capacity (cm3)	.241	.210	**.925**	-.110	.018	.155
Zscore: Saggital Crest	-.347	.098	**.664**	.649	.073	-.051
Zscore: External Cranial Base Flexation	.030	**.907**	.223	.334	-.029	-.118
Zscore: Depth of Mandibular Fossa	**.871**	.329	.246	-.122	-.170	.145
Zscore: Foramen Magnum/bi-tympanic	**.590**	**.550**	-.444	-.314	.167	.158
Zscore: Inclination of Foramen Magnum	.092	.385	.228	-.107	.852	-.180
Zscore: Inclination of Nuchal Plane	**.874**	.130	.149	-.253	.323	-.161

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
A Rotation converged in 12 iterations.

In Table 6, the significant values in each of the three components are in bold print for ease of reference. When evaluating each component, what emerges is the relationship as postulated previously. The first three components must not be considered as a 'pictured' progression of fetal development (due to the logistical groupings of components), rather as the overall relationship among these factors within cranial development. It is suggested that component one depicts the significance of the cranial base, whereas component two and three depict associations with cranial capacity. The indication of bipedality, as speculated by the inclination of the foramen magnum, is not seen as being significant until the fifth component. This also coincides with body weight. The reason for this placement remains unknown. Furthermore, the placement of other variables within these components was not expected. Under careful consideration, it appears that extraneous variables are the probable culprits of the variable distribution among the components allotted. However, grouping aside, the variables chosen appear to conform to some expectations. However, this analysis,

though proving the essential basis for this inquiry (cranial base), has failed to produce a single uniting factor that would indicate the existence of a universal factor; besides being well below any degree of criteria set by Hume in Part II, subsection 2.1. If resigned to this undesirable position, the author would have to capitulate due to the lack of scientific evidence supported by statistical analysis. Given an organism's process of actualization (maturation) from potentiality to actuality, there must be existent governing principles that are ultimately reflected in morphology. Though the author's initial intuition was confirmed by both individual correlations and factor analysis, perhaps further speculation based on greater degrees of intuition would prove to yield greater rewards.

Part IV

PRINCEPS NITOR HYPOTHESIS RECONSIDERED

Discovery of Commonalities: The Universal Hominidae Theorem and the Bipedality Index and Cranial Capacity/Bipedality Efficiency Index

4.1 This inquiry, as stated in Part III, did not yield results that would lead to a universal criteria for judgment in the construction of our species' phylogenic past. However, the correlations did vindicate that the basis for this scientific inquiry, the cranial base as suggested by many, was correct (Schafer 1999; Luboga et al., 1990). After a reassessment of the variables, it became apparent to the author that the following variables were of significant importance: foramen magnum, occipital condyles, opisthion to opisthocranion, foramen to bi-tympanic, brain weight, mandibular fossa to basion, and the inclination of the foramen magnum. These variables have a hidden relationship that has importance influence on cranial capacity, bipedality, and prognathism. These features, when taken independently as Hume suggests, can provide an excellent criteria by which to structure the objects of this inquiry. However, there can be no philosophical justification without commonalities that would ultimately reflect the dynamic changes within morphological characteristics. Thus, in pursuing commonalities, as Darwin himself suggested in Part I, subsection 1.2.1, careful notation must be made concerning the pursuit of this perspective. It is postulated that commonalities of morphological characteristics that result in cranial capacity, bipedality, and prognathism do not confer a progressive trend (directed teleology) but these morphological characteristics, when commonalities are applied, will challenge and change the defining Hominidae attributes for phylogenic purposes. This will translate into the refining of our own species, *Homo.*

4.1.0 Although the basi-occipital portion of the cranium holds promising keys to proper trait selection, however it became evident that this functional approach to morphological trait selection would require additional information within the pending conceptual framework. Using perhaps an unorthodox approach to this issue, it can be postulated that any deviated position of vertebra in the spinal column, particularly in the cervical and lumbar regions, will affect the bipedal experience (in varying degrees). From this perspective, the analysis of the basic function of the vertebral column was performed. What had emerged suggested that the foramen magnum (position) and occipital condyles have a direct relationship with the degree of bipedality via spinal column (particularly the curvatures), muscles, and center of gravity (Luboga 1990; MacLarnon 1994). Additionally, the bi-tympanic line would illicit the balance (via middle ear) necessary to articulate locomotion with the post-cranium (Robinson 1972). These two factors would suggest that brain weight (indirectly, cranial capacity) would have to be deferred across the area of the atlas and axis of the upper cervical column, ultimately aided by atlantooccipital joint and atlantoaxial joints and reinforced by both cruciate and alar ligaments. From these two initial vertebrae; force would be absorbed or diffuse by the cervical, dorsal, and lumbar curvature of the vertebral column (Gray 1995). Differences in the size and inclination of the foramen magnum could potentially be used to distinguish groups of specimens (not taxonomical relationships) from one another.

4.1.1 These conjectures about the forgoing variables appeared to be conjoined, especially within the context of experience. However, limitation associated with dislocation of vertebrae (and intervertebral disks) does not constitute a basis for a taxonomical system. Systems, especially when applied to Hume's criteria, needs to be grounded within a system of mathematics. During the early quarter of 2004, the author had an epiphany of scientific magnitude that resulted in three distinct sub-formulas that would eventually lead to both the Bipedal Index (Hominidae

Theorem) and Cranial Capacity/Bipedality Efficiency Index. Venturing into uncharted territory, the basis for this formula is more on acute observation and mechanical aptitude than the consultation of previous works or texts. In fact, previous works regarding speculation on bipedality and cranial morphology proved to be more a hindrance than a scholastic aid; for the justification for my premise has satisfactorily vindicated the initial postulation in Part III. From inclination to speculation, the postulated mechanical relationship materialized within two formulas. The constituents of the formula are expressed in sub-formulas. These three sub-formulas as depicted in Table 7, consists of Bipedality Sub 1 (BPI), Bipedality Sub 2 (BPII), and the area of the foramen magnum (FMA).

Table 7 BPI, BPII, FMA Formula

BPI

$a^2 + b^2 = c^2$

whereby (a) is the differentiated force of Basion central
whereby (b) is the differentiated force of Magnum base
whereby (c) is the Foramen magnum length
therefore
BPI = ½ (differentiated force of Magnum base x differentiated force of Basion central)

BPII

$a^2 + b^2 = c^2$

whereby (a) is differentiated force of the center of gravity
whereby (b) is the differentiated force of balance base
whereby (c) is the External auditory meatus/ Opisthocranion line + Bi-tympanic line
Therefore
BPII = ½ (differentiated force of the center of gravity x differentiated force of balance base)

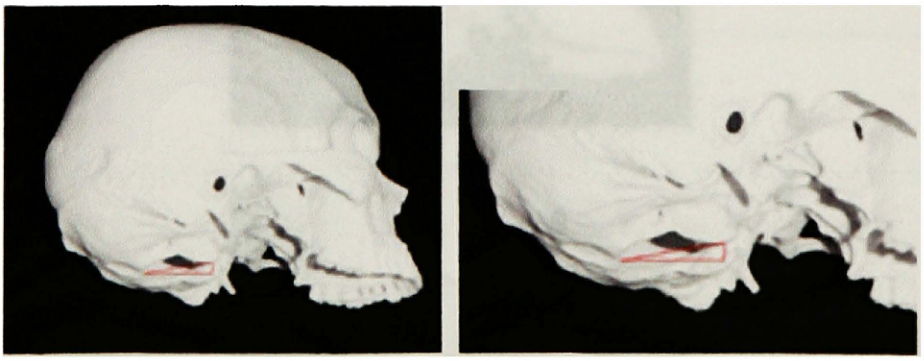
Foramen magnum area

FMA= 3.141592 (Foramen magnum length/2) (Foramen magnum breadth/2)

** Differentiated force is due to effects of muscles and ligaments on the cranium

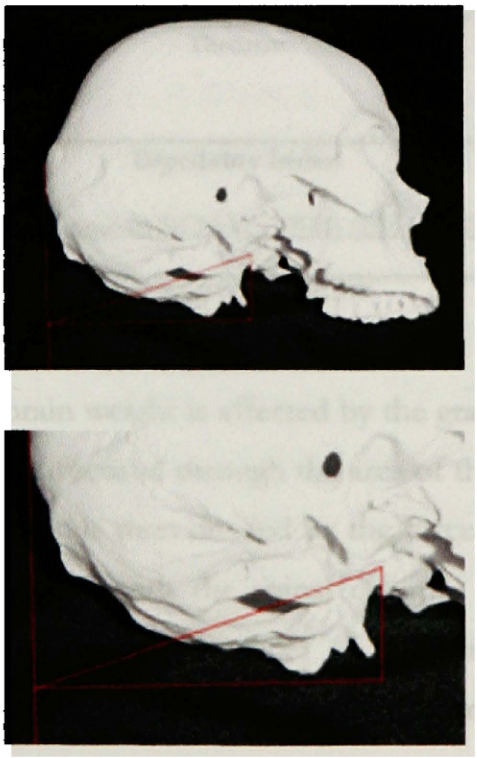
4.1.2 Viewing the cranial base (inferior view), the variable BPI consists of the area of the foramen magnum by which both the atlas and axis (C1 and C2) articulate with the cranial base/occipital condyles. Though not considering the area of the foramen magnum as comprehensive part of BPI (whereas FMA is a variable in itself), the functional role of the foramen magnum becomes contingent upon the distributing factor of the weight initially balanced (static) and deferred across the atlas and axis. It is in the unique symbiotic role shared by the atlas and axis that combines and not excludes one at the sake of the other. Together, the atlas and axis combine in one distinguishable role: articulate movement of the cranium. As indicated by Table 7, BPI (Bipedality Sub I) consists of two points which then are distributed across an area. Forming a triangle, line A is from what the author terms as Basion central. This particular point serves as pivot by which the foramen magnum length, line C, acts as force that produces the differentiated force along the magnum base, line B. The area consists of both the differentiated force of Magnum base and differentiated force of Basion central. This area indicated by Figure 4 illustrates the distributing force that would be exerted upon on both the atlas and axis vertebrae; all of which would be dissipated through the curvature of spinal column to the pelvic girdle and remaining lower extremities.

Figure 4 BPI



4.1.3 The nature of BPI, in itself, is only half of the issue concerning the mechanical properties under consideration. Though the majority of the brain weight would be distributed upon this sub-area (accentuated by the inclination of the foramen magnum), the functionality of locomotion, thus bipedality, remains contingent on BPII. As depicted in Figure 5, BPII or Bipedality Sub II is related to the dynamic balancing providing by the inner ear or labyrinth. Consists of a triangle where line A is the differentiated center of gravity. Line C is from the external auditory meatus to the opisthocranion. With some hominid species, an additional line is required from the bi-tympanic line to the basion. Line B is considered as being the differentiated force of the balance base. The area is produced from differentiated force of the center of gravity and differentiated force of balance base. This is illustrated in Figure 5.

Figure 5 BPII



The Foramen Magnum Area (FMA) variable indicates a unique process by which both form and function contribute to hominid designation. The foramen magnum allows for the medulla oblongata (including membranes), spinal nerves, vertebral arteries, and anterior/posterior spinal arteries to pass through the cranium. Although it can be speculated that an increase in the area of the foramen magnum would be indicative of both size and complexity of the brain, the involvement of this area in regards to the degree of bipedality would be reflective in the inclination and possibly in the cranial base flexation. The distributed weight of the brain and the disseminating central nervous system hinges upon the area of the foramen magnum (Gray 1995). This sub-formula pertaining to the area of the foramen magnum not only serves as three dimensional aspects but also serves in relation to cranial capacity. Together, the author postulates that these factors exhibit themselves as a Universal Hominidae Theorem as seen in Table 8.

Table 8 Bipedality Index, the Universal Hominidae Theorem

Bipedality Index

$$\frac{[(\text{Brain Weight})\,(\text{Gr. Constant})][\text{FMA}]}{100} \Big/ [(\text{BPI})\,(\text{BPII-BPI})\,(\text{Gr. Constant})]$$

In Table 8, the variable brain weight is affected by the gravitational constant (980 cm/sec/sec), which then is focused through the area of the foramen magnum via brain stem. This relationship is then divided by the force produced by both BPI and BPII which is integrated with the spinal column. It must be noted that reflected within this formula, the influences of neck muscles, particularly the sternocleidomastoid, trapezius, splenius capitis, semispinalis capitis, and

longissimus capitis aid in the differentiation of force as depicted in subsection 4.11 of this Part. Though the gravitational representation is cancelled mathematically, they are included in the tables to illustrate the context by which the relationships exist. Based on the exerting influence of gravity, it is further postulated that the gravitational constant on other planets, should the evolution of complex organisms exist, will remain influential on various forms of life. In what H. James Birx terms exoevolution, the possibility concerning the exoevolution of hominid forms would be continuously subjected to the selective pressures of physics throughout their evolutionary existence. In regard to the Hominidae Theorem, the outcome is a number that reflects the dynamic morphological characteristics that were sought in Part III. These numbers therein do not indicate a progression but provide a relative reference in accord with other specimens. However, bipedality is not the complete scenario that should be taken in consideration. In terms of evolution, efficiency becomes essential.

4.1.4 Based on the processes found within the Hominidae Theorem, inquiry into the efficiency between cranial capacity and bipedality became a natural progression. Efficiency, in this manner, does not signify the efficiency in terms of locomotion (Kramer et al., 2000; Rodman et al., 1980). Rather, efficiency is in terms of cranial capacity in relation to the expressed point of bipedality (diminished returns). Since cranial capacity does **not** infer complexity or efficiency, although endocasts and locomotion can postulate behavior capabilities (Luboga 1990; Lieberman 1997), the degree of efficiency can be a point of relative reference by which to define our species. The relationship between BPI and BPII is postulated as having a correlation with the efficiency of a bipedal system of locomotion reflected in cranial morphology. To express this speculation, as indicated in Table 9, cranial capacity is divided by the area of the foramen magnum. This is due to the functional nature of the foramen magnum and its relation to morphological features of the cranial base. This mathematical

representation, along with the Bipedality Index, could replace the erroneous and arbitrary 'Cerebral Rubicon" of 750 cc as postulated by Sir Arthur Keith (Montagu 1961).

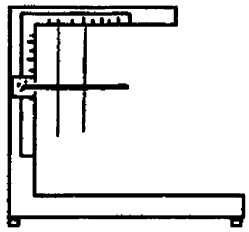
Table 9 Cranial Capacity/Bipedality Efficiency Index

Cranial Capacity/Bipedality Efficiency Index
Cranial Capacity Foramen magnum area

In order to acquire data pertinent to the formula, and since equipment for this inquiry is non-existent, the construction of a suitable apparatus became of critical importance. This resulted in the author's conception and construction of the Cranial Bipedality Index Stand.

4.1.5 Resembling a rather crude but effective tool from the Seventeenth Century, the Cranial Bipedality Index Stand was built to the author's specifications. Careful attention was paid to ensure the stand being square and level. Constructed of wood, a metal (scaled) square was installed for measurement purposes. As depicted in Figure 6, the stand includes the following: plumb lines secured by magnetic tabs located on the square rule, bubble level, and a magnetic protractor (180 degree).

Figure 6 Cranial Bipedality Index Stand



Cranial Bipedality Index Stand

After making sure that the stand is adjusted to being level, each specimen was secured in the upper left corner (as seen in Figure 6); whereby the Frankfurt Horizontal would be 180 degrees or parallel with the bottom of the stand. Plumb lines were then place indicating the Basion Central, External Auditory Meatus, and Opisthocranion points. Measurements were then acquired for the differentiated force of the Magnum base (BPI) and the differentiated force of the Balance base (BPII). Since the measurements pertaining to foramen magnum length (BPI) and the external auditory meatus to opisthocranion (if necessary, including the bi-tympanic line) can be constructed with existing data, the remaining data can be established by mathematics. Table 10 reflects the calculations of both Bpi and CC/BPEI for each of the specimens used during this inquiry.

Table 10 Bpi and CC/BPEI Variables

Species	Bpi	CC/BPEI
A. afarensis	14.40	.9410
A. africanus	14.06	.9860
A. robustus	17.75	.5870
A. boisei	18.26	.5870
H. habilis	39.20	.9580
H. egaster/ erectus	28.00	1.6100
H. sapiens	32.99	1.3800
Pan	21.18	.6930

Terms of Significance

4.2 Utilizing SPSS, version 12.0, a bivariate correlation yields the following Pearson's correlation with a two-tailed test of significance. Appendix B depicts the results relating to both the variables included within the formula and with previous variables. Careful analyses of the internal correlations yield significant results. The foramen magnum area (FMA) had high correlation with BPI and less significant correlation with BPII. Though this was expected and can be explained by the properties of the formula, the remaining internal correlations were surprising. High correlations (where r = .05 and .01) were seen concerning cranial capacity and brain weight. In this regard, BPII has a significant correlation to both cranial capacity and brain weight. Furthermore, the variable cranial capacity/bipedality efficiency index holds significant value in both of these aspects. Other interesting correlations emerged in relation to other variables. Aside from the expected correlations regarding the dimensions of the foramen magnum, the correlation of the foramen magnum area upon the occipital condyle length and breadth was unexpected (whereby r > .5). Another unexpected correlation involved BPI and Nasal breadth (r > .6). The last variable of unexpected correlation is BPII (r > .6) and CC/BPEI (r > .6) and opisthion to opisthocranion variable. Granting the fact that the formula and variables intended

to have empirical 'check and balances' regarding morphology and function, the correlative values set forth by the statistical analysis appears to support the postulated universality of both the Bipedality Index (Hominidae Theorem) and Cranial Capacity/Bipedality Efficiency Index as stated in the beginning of Part IV.

4.2.0 Further analysis was performed on the variables suggested in subsection 4.3. Using the same criterion as depicted in Part III, subsection 3.31, a factor analysis was preformed using the new variables. The results had met (and exceeded) the initial expectations assigned prior to the postulated events leading to the analysis. When comparing and contrasting Table 5 and 6 (without formula) with Table 11 and 12 (with formula), the addition of the formula had significant influence on both the rotated component matrix and the total variance explained. As for the total variance explained, there was an increase from 57.635% (without formula) to 60.218% (with formula) by the third component. Although an overall increase of **+2.58%** indicates the explanative power of the postulated formulas, the explanative percentage within the first two components shifted, +5.386 and +6.726 respectively, when the formula was applied. The shifts in the first two components are due to changes within the significance of the variables within each component. It appears that the formula had reduced or **refined** the first two components.

4.2.1 In component one, the correlation between the foramen magnum (length and breadth) and the strong relationship with the foramen magnum area (FMA) and BPI is evident. Furthermore, the relationship to the bi-tympanic line becomes critical when the conjoining factors (BPI and later – BPII) are solidified during development. This would explain the high correlative value of the external cranial base flexation that would otherwise be regarded as 'misplaced' variable.

Table 11 **Final Total Variance Explained**

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.302	34.593	34.593	8.302	34.593	34.593	6.070	25.293	25.293
2	5.230	21.793	56.386	5.230	21.793	56.386	4.859	20.244	45.538
3	4.159	17.328	73.714	4.159	17.328	73.714	3.523	14.681	**60.218**
4	2.692	11.219	84.932	2.692	11.219	84.932	3.348	13.950	74.169
5	2.191	9.127	94.059	2.191	9.127	94.059	3.077	12.819	86.988
6	1.210	5.041	99.101	1.210	5.041	99.101	2.907	12.113	99.101
7	.216	.899	100.000						

Extraction Method: Principal Component Analysis

Table 12 **Final Rotated Component Matrix(a)**

	Component					
	1	2	3	4	5	6
Zscore: Body Weight (g)	-.180	.074	.254	.169	.084	.925
Zscore: Brain Weight (mg)	.295	**.901**	.101	-.231	.047	.182
Zscore: Foramen Magnum Length (mm)	**.900**	.370	.079	.185	-.099	-.041
Zscore: Foramen Magnum Breadth (mm)	**.915**	.301	.245	.001	.106	-.013
Zscore: Mandibular Fossa/Basion (mm)	-.256	.211	**-.870**	.272	.062	-.227
Zscore: Opisthion/Opisthocranion (mm)	-.005	**.558**	**.699**	-.018	.000	.446
Zscore: Hormion/Basion (mm)	-.087	-.069	-.323	.322	.836	-.284
Zscore: Nasal Breadth (mm)	.320	-.098	-.073	-.106	.889	.177
Zscore: Nasal Height (mm)	.460	.266	.053	-.276	.594	-.423
Zscore: Occipital Condyle Length (mm)	.448	.319	-.397	.660	.222	-.234
Zscore: Occipital Condyle Breadth (mm)	.460	**.583**	-.403	.009	.264	-.462

Zscore: Cranial Capacity (cm3)	.276	**.934**	.046	-.183	-.107	-.011
Zscore: Foramen Magnum Area (mm)	**.910**	.352	.186	.099	-.001	-.041
Zscore: Biped sub1 Area (mm)	**.885**	-.090	.122	.098	.421	.082
Zscore: Biped sub2 Area (mm)	.238	**.837**	.183	.446	.051	.079
Zscore: Bipedal Index	.371	.418	.049	-.775	-.290	.010
Zscore: Cranial Capacity/Bipedality Efficiency Index	-.302	**.655**	.106	-.447	.111	.505
Zscore: Saggital Crest	.085	.488	-.356	-.442	.647	.115
Zscore: External Cranial Base Flexation	**.872**	.063	.014	-.418	.247	.026
Zscore: Depth of Mandibular Fossa	.463	.419	**.702**	.174	-.148	-.238
Zscore: Foramen Magnum/bi-tympanic	**.619**	-.273	.510	.371	-.360	.121
Zscore: Inclination of Foramen Magnum	.332	.189	.126	-.170	-.145	.876
Zscore: Inclination of Nuchal Plane	.191	.298	**.842**	.071	-.287	.274
Zscore: O-M Sinus in Hight Frq	.143	-.055	.045	.952	-.241	.088

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. A Rotation converged in 9 iterations.

4.2.2 The second component reflects the nature of variables associated with BPII. In this category, the influencing factors within BPII, including brain weight and cranial capacity, would have a correlation with the occipital condyles (breadth). This stands to reason, for this relationship would manifest itself in the significant correlative value of the Cranial Capacity/Bipedality Efficiency Index. This category is of particular interest. It can be postulated that in the second component, the influencing factors from the first component must interact in a manner that is sufficiently viable for the development of the cranium and to support the weight of the developing-(ed) brain. The low correlative value for the

inclination of the foramen magnum is perplexing. However, future analysis may shed light on this variable.

4.2.3 The third component can be considered as being related to prognathism. The high negative correlation with the mandibular fossa to basion, significant correlation with foramen magnum to bi-tympanic line and high correlative value with the expansion of the occipital region suggest a reduction in prognathism. Furthermore, the high correlative value of the depth of the mandibular fossa and negative correlation with saggital crest would indicate the effect of reduction on the relationship with mastication; particularly with both the temporalis and medial pterygoid muscles (relative to the temporal fossa and sphenoid bone respectively). However, the significance of the inclination of the nuchal plane in the third component remains a mystery. It has no logical basis within this component, though having more of a relationship (anatomically speaking) to the first two categories. It may be speculated, and rightfully so, that the formulas presented thus far are just one step in a sequence of factors. A final analysis of variable relationships will be preformed in Part VI, subsection 6.2.

4.2.4 In order to proceed with the relevancy of the two indexes in regards to taxonomical evaluations, a brief synopsis regarding this inquiry is in order. Taxonomical systems, by their nature, are embedding with epistemological problems. Metaphysics from Aristotle to Linnaeus has constructed an enduring system of classification. However, evolution as postulated by Darwin had changed this perspective. The significance of traits becomes a central issue. With the progression of modern science, the understanding of biological (including genetic) and physiological processes have cast doubt upon the reliability of morphological traits used in taxonomical assessment. Skelton et al. (1986) exemplified the problem and possible solutions by the brilliant conception of complexes. This logical and progressive manner exposed the plasticity of featured

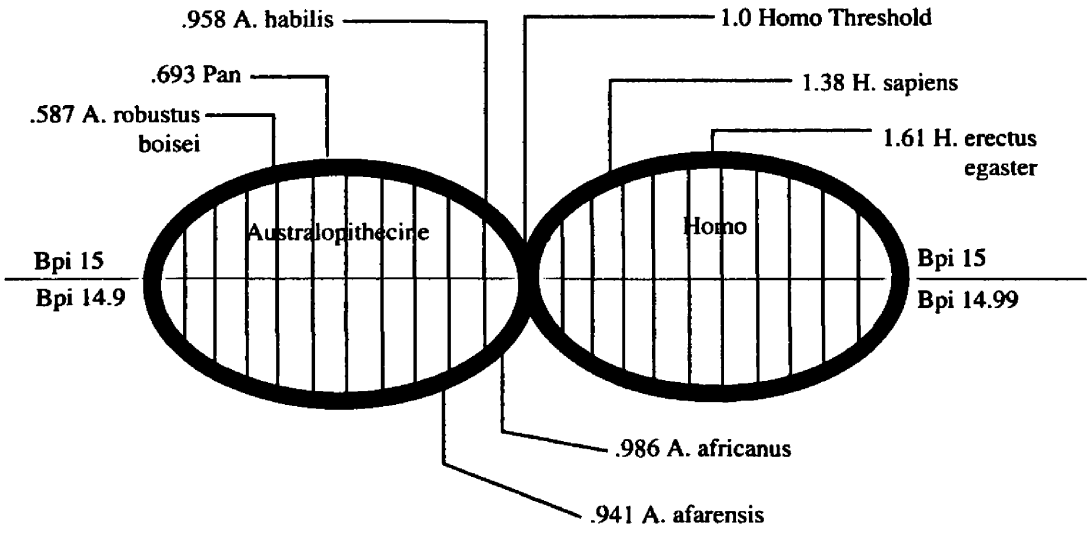
traits. However, the author contends that there exists a universal process by which an evaluation can be determined – that being the morphology of the cranial base. Using the philosophical perspectives presented by David Hume, the distinguishing of 'matters of fact' from the 'relation of ideas' had removed the problem of causality from the taxonomical structure. With reduced skepticism, embryology was seen as a guide to the evaluation of cranial base features. After compiling a relevant list of morphological traits, significant correlations did emerge. Furthermore, factor analysis had determined both the percentage of explained variance and related the variables within components. However, this did not grant the predictive power sought by establishing a universal formula. This would require more time and deliberation.

4.2.5 After a period of time, a punctuated thought had occurred that resulted in the creation of the bipedality index and the cranial capacity/bipedality index. This unique perspective included the basis of embryology and fetal development with physics. Utilizing mathematics, the author was able to ground these 'matters of fact' with the 'relation of ideas' that was explained in Part II. The resulting formula(s) proved to be significant among many variables, which then was reflected by the percentage of explained variance in the factor analysis. Furthermore, components within the matrix grew in their significance and organized themselves into discrete categories that resemble distinctions in cranial development. Though the 'spirit of Hume' had never deviated from this inquiry, NO CAUSAL relationships among taxons have yet been established. For Phylogenetic purposes, any definition of hominid species becomes contingent on the defining properties of what can be deemed as *Homo*. This will lead to the next discourse.

Defining the *Homo* Threshold

4.3 As with all philosophical and scientific inquiries, ontology becomes an important and complicated issue, as depicted in Part I. In this manner, this inquiry is not different. As stated in Part IV, subsection 4.14, the relevancy of these formulas is to provide an accurate and independent depiction of our species in relation to fossil hominids. This relationship among taxons, when proceeding from the resulting Hominidae Theorem by which both the bipedal index and cranial capacity/bipedality efficiency index stems, can be viewed in the figure below. When complied together, the result is a postulated threshold by which defines what we would term as *'Homo'*. Though not a linear progression, specimen placement will express the relative proximity in regards to the defining properties of our species. Although this is pure speculation based upon both valid and postulated theoretical evidence, it nevertheless provides fertile ground for future discourse.

Figure 7 Homo sapiens Threshold



Consisting of a modified infinity symbol, Figure 7 depicts two elongated circles that philosophically encompass the theoretical possibilities of organic evolution. The left side is designated as consisting of hominids forms deemed as 'Australopithecines' and the right side designated and consisting forms termed as '*Homo*'. Though these terms are categorical, thus subject to multi-fortuitous augmentation in their labeling, the left side encompasses all hominid forms that possesses CC/BPEI less than 1.0 (*Homo* Threshold) and the right side are those forms that posses CC/BPEI greater than 1.0. The red line, signifying the Homo threshold, is based on perfect efficiency (cranial capacity to bipedality – BPI to BPII). The blue line dividing the circles in half relates to the bipedality index; whereby any Bpi equal or greater than 15 is placed on the upper portion and any Bpi 14.99 and lower are placed on the lower portion. The parallel lines indicate the possibility of parallel evolution. Species are then allocated by their respective BPI and CC/BPEI numbers. This figure does not depict descent but **relative** relationships among taxons. The designation '*Homo*' is seen as a relative term, for it challenges the traditional ontological and teleological concepts assigned to and relished by our species. This is expressed in terms of both complexity and associated behavior as a species nears the threshold of 1.0. The author's speculation concerning this threshold is a reflection on the evolution of the primate brain with bipedality.

4.3.0. During the evolution of our species, a qualitative leap or a period of cerebral punctuation had occurred in the evolution of the human brain. The result of this punctuation manifests itself in greater degrees of neural complexity and cognitive functions. In a theory postulated by Blumenberg (1983), the reorganization of the primate brain may have taken very little time, evolutionarily speaking. Postulated as the *Model of Advanced-Brain Evolution*, neural reorganization has been taking place throughout hominid evolution. Accordingly, it is postulated that the presence of methylated cytosine in nucleotides may be responsible for

rates by which mutations take place and subjected to natural selection. Once significant mutations had taken place, the resulting mutations would be a cause for a Founder effect, whereby deviation and or chromosomal transilience will result (high probability) in greater distance between ancestors and descendents. From these mutations, it is postulated that cytological changes to the primate brain, particularly brain peptides, nerve cell differentiation, synaptic connections, and number of cells per unit of cortical volume (including greater complexity), had resulted in significant changes in the structure and function (in terms of behavior) of the brain. Such changes probably resulted in new behaviors, fostered by an increase in the capacity of memory and the ability for prediction, which placed an emphasis on social behavior and the acquisition of diverse sources of food. Such changes in diet could affect neural activity, e.g., an increase in tryptophan and tyrosine. After mutations had occurred, the relationship among mental activity, behavior, and diet created a stabilizing cyclical factor that promoted homoeostasis (Blumenberg 1983; Holloway 1966; 1981; 1982).

4.3.1 The preceding overview suggests one possible scenario concerning the evolution of the brain. Although cognitive and neurological sciences have made advancements in understanding the human (primate) brain, certainly both the physiology and neural activity of the human brain are too complex, and too much is unknown about the resulting cognitive functions in order for a complete analysis to be preformed. When applying this inquiry to the fossil record, it becomes impossible. However, when taking in consideration endocasts, it appears that the hominids possessed, to varying degree, an increase in the cerebral cortex and the presence of cerebral symmetry. Though the location of the Lunate Sulcus (separates the posterior visual cortex from the parietal lobe) on some specimens may be controversial, the effects inferred from the pretrial patterns, e.g., Broca and Wernicke's area, suggest that mechanical dexterity and the foundation for language capabilities were present during the

Australopithecine and later stages of evolution (Blumenberg 1983; Falk 1987; 1988; Holloway 1966; 1981; 1982; 1988).

4.3.2 When considering hominid endocasts and the genetic plausibility of neural reorganization, the chasm among our species, other hominid forms, and the great apes begins to narrow. Granting that these postulates will never be certain, the relationship as depicted in Figure 7 illustrates two important factors. First, cranial capacity/bipedality efficiency index and the bipedality index have an intricate relationship. The dimensions of the foramen magnum (FMA) have particular importance regarding blood supply to the brain (via vertebral arteries). Indirectly (via BPI and BPII), FMA would have importance concerning cranial capacity. Second, there must be an indirect relationship between neural complexity, as described in the previous subsections, and the emergence of bipedality as postulated in Part IV of this inquiry (as illustrated in the case of *H. habilis*). Though this can never be certain, the endocasts and evidence of the archaeological record appear to support (in degree) the behavior of hominid expressions, e.g., Olduwain culture, stemming from this growing complexity. Since cranial capacity is irrelevant in the definition of "*Homo*" and behavior is not exclusive to the same category, the *Homo* threshold was set using the maximum 'efficiency' that can be expressed concerning the relationship among the variables within the formulas established previously by the author. It is upon this perspective that the author postulates the context by which our species should be viewed; a product of gradual evolutionary change with punctuated neural reorganization (Blumenberg 1983; Gould 2002).

4.3.3 Upon utilizing the *Homo* Threshold, there exists one significant change to the assigned taxonomical designations. As depicted in Figure 7, *Homo habilis*, though exhibiting similar Bpi to *H. sapiens* (39.20 and 32.99 respectively), the CC/BPEI (.958 and 1.38 respectively) clearly assigns this specimen to the

Australopithecine category. The difference between *habilis* and *sapiens* illustrates the intricate relationship between BPI, BPII, and CC/BPEI. A high Bpi index does not indicate a high CC/BPEI index rating; although significant correlation exists between CC/BPEI and BPII (via the effect of FMA of BPI) and cranial capacity as depicted in Table 16 of Part IV. Based on the forgoing formula, it is postulated that *Homo habilis* should be deemed as *Australopithecus habilis*. Although the naming of specimens may become moot, the mathematical designation used to define two categories becomes highly relevant.

4.3.4 In terms of Hume set forth in Part II, causal connections among specimens were removed and the 'matters of fact' were substantiated by the 'relation of ideas' that was given by mathematics. The independence that was given to each specimen results in the discrete placement into two categories. Further divisions and creations of named categories can be implemented when the Bpi and CC/BPEI deviate **greater than 10%** (reflecting the degree experienced during maturation). Though this is highly speculative, the author postulates that the reexamination of the fossil evidence would indicate a great amount of variation expressed in the gradual evolution to *H. sapiens*. Furthermore, it is speculated that these variations probably involved many instances of parallel evolution. Evidence to support this conjecture could only be substantiated by the examination of known hominid specimens by the criterion established by this inquiry. In terms of phylogenic analysis, which is the ultimate purpose of this inquiry, the stringent criterion presented herein selects those traits that will be subjected to cladistic analysis.

Part V

PHYLOGENETIC ANALYSIS

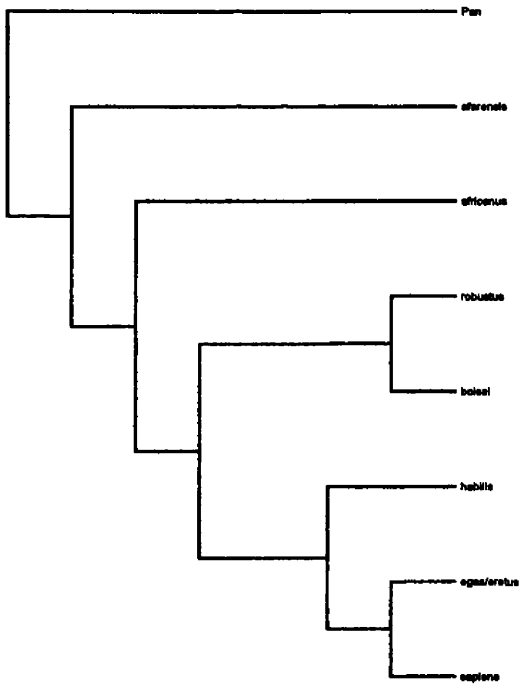
Cladogram and Hominid Phylogeny

5.1 There will be several contended traits that will be used for the construction of a cladogram. The first set of variables will include all significant variables (see Appendixes A and B). The second set will include those variables from the factored analysis in Part IV (Table 12). The remaining sets will exclude variables until the most derived parsimonious traits are both reduced to a minimum in both number and required evolutionary breaks, the result of maximum parsimony (Skelton et al., 1986). Appendix C indicates the initial set used for analysis. Due to either plasticity or inadequate correlative value to either Bpi or CC/BPEI, the OM sinus and nasal variables were not under consideration.

5.1.0 Each species was assigned its variable's value based upon the data taken from Table 4; whereby *Pan troglodytes* was established as possessing the most primitive traits. Using Paup 4.0, the Nexus data matrix consisting of 8 taxa and 19 characters yielded an interesting cladogram (See Appendix C). In Figure 8, the cladogram postulates the approximate relationship based on derived parsimonious traits. As depicted, *H. sapiens* and *H egaster/erectus* have derived traits from *A. habilis* (former *Homo*); a designation as previously stated in Part IV, subsection 4.4. *A.* (*H*) *habilis* is one of two branches that are derived from *A. africanus,* whereas the other branch consists of the robust Australopithecines. This is probably due to factors resulting in parallel evolution (or an unknown species) than any one particular parsimonious trait. The remaining species does not deviate from providing the maximum parsimony; A. *africanus* deriving traits from *A. afarensis,* which derived its primitive trait base from ancestral *Pan troglodytes.*

This cladogram does not differ much from the most parsimonious cladogram postulated by Skelton et al. (1986). Differences are seen in both the robust forms of Australopithecines (parallel evolution) and the designation of *habilis*. Furthermore, the author confirms Skelton et al. possibility of an unknown species before the major split. Nevertheless, as with the complexes stated in Part I, subsection 1.6, further inquiry resulted in a reduction of traits used for analysis.

Figure 8 Postulated Cladogram



5.1.1 A second analysis was preformed using Paup 4.0. Using the same criterion as established in 5.10, only 16 characters underwent analysis: brain weight, foramen magnum length, foramen magnum breadth, mandibular fossa to basion, Opisthion to Opisthocranion, occipital condyle breadth, cranial capacity, foramen magnum area, BPI, BPII, bipedal index, depth of mandibular fossa, external base

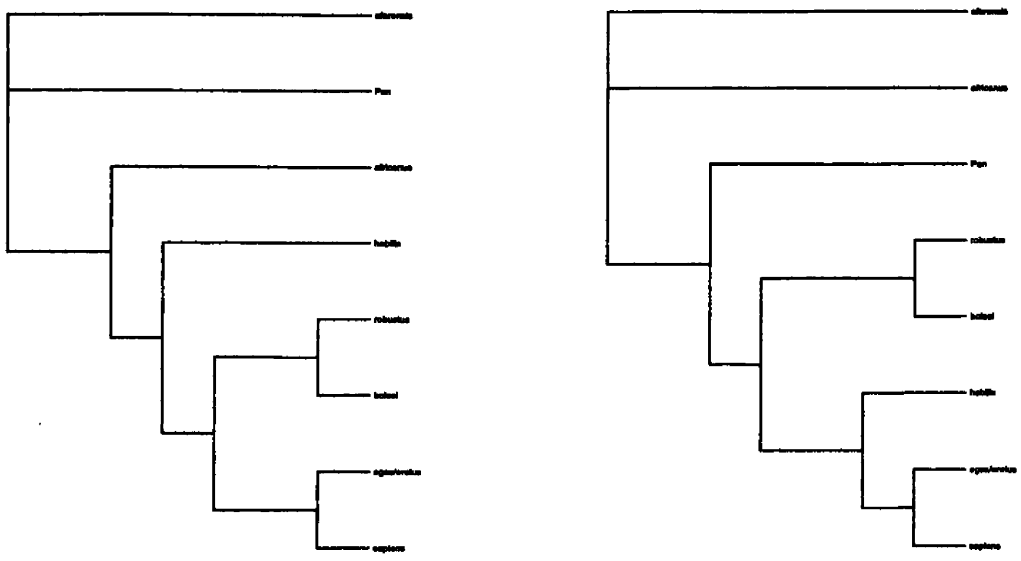
flexation, inclination of the nuchal plane, foramen magnum to bi-tympanic line, and cranial capacity/bipedality efficiency index. The resulting cladogram remained identical to the cladogram depicted in Figure 8. It became highly suggestive that the remaining traits would fall into two categories: accidental, whereby the results will remain the same; and essential, whereby the removal of said traits would render the cladogram incompatible, as depicted by the complexes expressed by Skelton et al. (1986). In the following procedure, classical experimentation would yield an unlikely result.

5.1.2 Each of the remaining variables in Appendix C was tested for final evaluation. Those variables that did not change the cladogram were rejected and those of significant influence were retained. Each variable, though statistically significant, was tested for cladistical relevancy. The results indicated that three of the sixteen variables possessed cladistical relevancies. Those variables include: brain weight, foramen magnum area, and mandibular fossa to basion. Each one of the three variables was then removed, assessed for relevancy, and returned to the matrix. The consequences of these variables are seen in Figure 9. As illustrated in both Figures, the two variables, brain weight and foramen magnum area, produce the same cladogram. However, the mandibular fossa to basion variable produced a different cladogram. Two species are affected, phylogenic speaking, by these variables: *Pan troglodytes* and *Homo habilis*.

5.1.3 Upon initial investigation, each of the three variables proved to be critical in establishing the parsimonious relationship as depicted in Figure 9. The removal of the brain weight variable caused a shift in the relationship concerning *habilis*. The same shift occurs in Figure 12 concerning the foramen magnum area variable. Though *habilis* could be contended as ancestral to both robust Australopithecines and *Homo*, as Skelton et al. (1986) suggests, the remaining variable posses both statistical and cladistical significance. As suggested by the

cladogram, the mandibular fossa to basion variable causes a shift in the *Pan troglodytes* species. Since *Pan troglodytes* is considered to posses the most primitively derived traits, the significance of this variable appears to be critical in the overall assessment concerning the derived parsimonious traits.

Figure 9 Variables: Brain weight and Foramen magnum area (left) and Mandibular Fossa to Basion (right)



5.1.4 Reduction from sixteen to three traits was unexpected and somewhat disconcerting. The remaining variables of brain weight, foramen magnum area, and the mandibular fossa to basion appear to have an interdependent relationship, via correlative values set forth in Appendixes A and B. These relationships, when taken individually, cannot account for the reduction and significance of the three variables. The solution to this perplexing result is due to the phenomenon regarding the formula used in assessing bipedality. As indicated in Table 7, Part IV subsection 4.11, brain weight and foramen magnum area

(disregarding gravitational constant) are exactly represented by two of the three remaining variables. The final variable, mandibular fossa to basion, is represented by the second half of the formula as in Table 7, albeit **indirectly**. As depicted in Table 13, the value of the mandibular fossa to basion variable, when divided by the resultant division of BPII by BPI, is a resulting number that has a high correlation (negative) to the opisthion to opisthocranion variable and the inclination of the nuchal plane. This is possibly due to the location of the mandibular fossa to basion in regards to the sphenoid bone, whereby cranial capacity and prognathism would ultimately be affected. The postulated indexes as posed by the *Princeps Nitor* hypothesis do offer a valid alternative to the foregoing method of phylogenetic analysis.

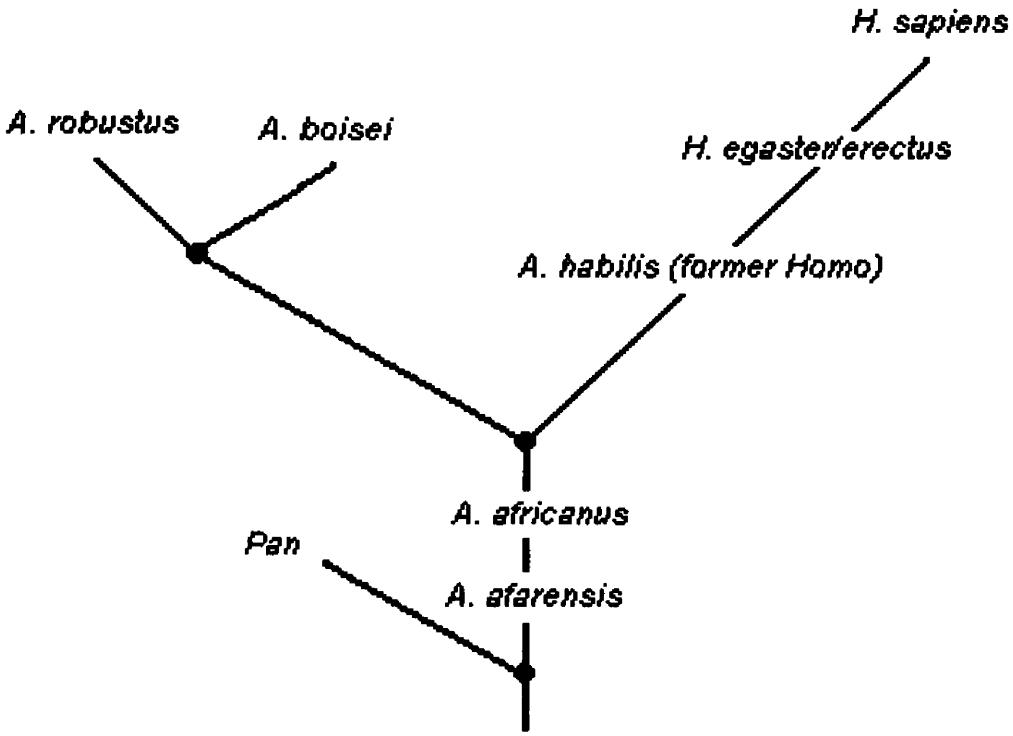
Table 13 Prognathism: The MFB/Bpi sub Variable

MFB BPII/BPI

5.1.5 Though the cladogram postulates a probable scenario, the guiding factor in phylogenic reconstruction is arranging the species according to determined age and according to the established cladistical relationship of derived parsimonious traits. Upon comparing and contrasting the cladogram in Figure 8 with the phylogeny in Figure 10, there remains a high probability of an unknown hominid form after *A. africanus* and before the major hominid split. Without conclusive evidence, the postulated phylogeny will be based on species presented in Part III. According to the fossil record, the established dates of species, as presented in Part I, subsection 1.5.0-1.5.6., the species and dates are as follows: *A. afarensis* (3-5 m. y. a.); *A. africanus* (1-3 m. y. a.); *A. robustus* and *A. boisei* (1-3 m. y. a.); *A* (*H*). *habilis* (2.6 m .y. a.); *H. erectus/egaster* (1.7 m. y. a.). *H. sapiens* is relatively new

(45,000 years ago to present) and *Pan troglodytes* ancestral divergence is suggested around 8 million years ago. Given these postulated dates and the cladistical relationship set forth herein, the resulting phylogeny is indicated in Figure 10.

Figure 10 Postulated Hominid Phylogeny



Scenario

5.2 The narrative concerning hominid phylogeny has expressed itself in a multitude of possible depictions. As indicated in Part I, subsection 1.5.7, these phylogenies are based upon traits and sequences in the fossil record. In the same manner, the author will construct a scenario that best fits the evidence and the fossil record. The ensuing postulation is not immutable, for both the incomplete

fossil record and the lack of examining known specimens (both severe limitations) may contribute to distorting both phylogenic reconstructions and the creation of new taxons. However, given the supposition of the *Princeps Nitor* hypothesis, the postulated hominid descent can be represented in the following scenario.

5.2.0 It is speculated that the oldest common ancestor, *Proconsul,* dates to around 18-20 million years ago. The split between our species and *Pan* is speculated as being as little as 6 million years ago; all of which is supported by genetics (Corballis 1999; Washburn 1974). During this period of time, it is speculated that several factors continued to result in the *accumulative* effects of morphological variation, e.g., phenotypic expressions and a reorganization of the hominid brain. These variations, perhaps accentuated by environmental factors, accelerated the qualitative differences that are now apparent between our species and the chimpanzees (Blumenberg 1983, Dawkins 1976; 1982; 1995; Gould 2002; 1989). Perhaps this can be depicted as a case of parallel evolution 6 million years ago, whereby the progressive trend can be seen in *A. afarensis.*

5.2.1 *A. afarensis*, around 3 to 5 million years ago, already developed an increase in many important traits. An increase in postulated stature and locomotion are reflected in the differences in both the postulated Bpi and CC/BPEI indexes. Though not much can be speculated concerning *afarensis'* ancestors, though perhaps *A. anamensis* could give an indication, it can be postulated that *A. afarensis* was bipedal and possessed a degree of prognathism (see Appendix E). This is supported by other morphological features. However during this duration, morphological changes had occurred that resulted in speciation. About 1 to 3 million years ago, *A. africanus* exhibited advancements in certain morphological areas. Though the Bpi index remained relatively the same, there was an increase in cranial capacity, BPII, and mandibular fossa to basion. These variables, along

with a change in the depth of the mandibular fossa, indicate that there is a reduction in prognathism and a modification to the mastication system (via MFBPI). Furthermore, an increase in the CC/BEI index indicates a greater efficiency among the conjoined traits and their probable behavior patterns conditioned by environmental factors as suggested by Skelton et al. From this hominid form two diverging lines of evolution occurred around 2.5 to 2 million years ago. One line resulted in *habilis* and the other resulted in the robust forms of Australopithecines.

5.2.2 Though it may be suggested that there is an unknown species prior to the spit, there is an indication that morphological features continued to be progressive. The robust Australopithecines, *robustus* and *boisei*, indicate shared affinities with each other that are acknowledge by academia. Though this analysis was limited, there is an increase in Bpi (FMA, BPI, and BPII) and a decrease in prognathism (as indicated by MFBPI). However, there is a significant decrease in CC/BPEI. This is not suggestive that extinction was due to inefficiency; rather, it is possible that competition due to parallel evolution had put emphasis on those hominids that possessed greater degrees of encephalization. In this manner, *A. (H) habilis* continued this trend that will eventually lead to *Homo.*

5.2.3 The other ancestral branch to *africanus* is *A.* (*H*) *habilis.* Around 2.6 million years ago, this hominid form continued the progressed increase in both bipedality index and CC/BEI index. Further reduction in prognathism and related dentition indicates a selective advantage regarding derived characteristics. This hominid form is postulated as being a transitional form between Australopithecines and *Homo.* The large Bpi number, relative to *Homo*, can be attributed to the assumptions regarding the symmetry of the cranial base (lowest resulting estimate Bpi is around 33.6). Although bipedal *habilis* is within the *Homo* range, ultimately the CC/BPEI designates this species as an Australopithecine. It is the

combination of these indexes that suggest the transitional nature of this species. Nevertheless, progression concerning both Bpi and CC/BPEI continued in the *Homo* (proper) line. Around 1.7 million years ago, *Homo egaster/erectus* continues this trend. Bpi and CC/BPEI indexes increased approaching near modern *Homo* standards. Furthermore, it is postulated that the advent of culture that is associated with Australopithecus (via endocasts), progressing toward *habilis*, had significant influences that are more pronounced with reduction of certain morphological characteristics that are significantly associated with Neandertals (Brace 2000; 1995; Dart 1982; 1994; Tattersall and Schwartz 2000).

5.2.4 Comparing and contrasting the author's phylogeny with those six phylogenies as stated in Part I, subsection 1.6-1.6.12, few interesting observations should be noted. Even if the species *Pan trogolytes*, *Homo egaster/erectus*, and *Homo sapiens* were eliminated from contention, the resulting phylogeny is similar to both Tobias (1980) and Skelton, McHenry, and Drawhorn (1986). The differences among phylogenies are limited to the robust forms of Australopithecines and the reclassification of *habilis*. Even regarding specimen condition, the refinement of trait selection (Hominidae Theorem) can account for both the distinction made between the two robust Australopithecines forms (parallel evolution) and the reclassification of *habilis*; whereby reclassification could not be justified under prior methodological criteria. The differences of remaining phylogenies of White et al. (1981), Olson (1981), Leakey (1981), and Boaz (1983), are most likely due to erroneous trait selection and possible methodological limitations.

5.2.5 When contemplating the evaluative effectiveness of the formulas incurred by this scientific inquiry, it appears that the *Princeps Nitor* hypothesis offers a degree of high probability in the assessment of hominid taxonomical placement. Expressed by this hypothesis, there exists more to characteristics (traits) than their visible morphology. Intricate interactions among an array of external

variables create multiple factors as an expressed holistically functional morphology. As illustrated with the both the Bpi and CC/BPEI formulas, many different forms of independent variables agree with individual segments of the formula, e.g., MFBPI index. Utilizing a degree of Hume's epistemology, the 'relation of ideas' contained herein does support the correlative relationship established among variables of the cranial base. Supported by statistics, the parsimonious derived traits have created a phylogenic tree that has roots extending back to 5 million years ago. The formula, by which this phylogeny was postulated, is not final; future refinements and new relationships in the postulated formula will continue to evaluate our phylogenic relationships to our hominid ancestors.

Part VI

PHILOSOPHICAL JUSTIFICATION

Principle of Universals

6.1 The extent of the postulated formula in the *Princeps Nitor* hypothesis goes beyond the definition of a hypothesis. Given the explanatory power and supporting independent variables confirming the essential basis established in Part III and Part IV, *Princeps Nitor* has developed into a working theory; a theoretical framework that is supported by physical and statistical evidence. However, the author deems this advancement from a hypothesis to a theory to be scientifically significant. Although multiple facets that remain unexplored up to this point, this inquiry, nevertheless, has successfully completed its objective. There remains, however, an epistemological query regarding methodology and the subsequently derived formula(s). This translates into the very heart of this scientific inquiry; is there a universal means by which hominidae taxonomy can be established? And which traits (particulars) influence the degree to which they contribute to the whole? Although cladistics tacitly acknowledges universals within a parsimonious context, cladistics fails to distinguish the principle components that become integral, as seen in Part I, subsection 1.6.12. This becomes problematic. The degree of methodological and taxonomical accuracy depends on the successful answering of these epistemological/phenomenological questions. Essentially, justification becomes necessary.

6.1.0 As illustrated throughout Part I, the underlying philosophical question is directly related to the existence of universals. Epistemological inquiry into this subject matter is important for theoretical sciences, e.g., anthropology and cognitive sciences, as it was for theological justification. Preliminary questions

pertaining to universals, as stated by Boethius (ca 480-525), are threefold: Are categories real or mental constructs? Are their realities based on corporeal or incorporeal perspectives? How do both perspectives interrelate with the whole? As seen with Aristotle, the subject and predicate relationship would have metaphysical implications for categorization. Ironically, it was the philosophical inquiry for theological justification, e.g., the Holy Trinity, which had stimulated the possibility for future scientific inquiry. During this period of inquiry, three distinct perspectives were created to answer these questions: Realism as postulated by Anselm (1033-1109), whereby a universal *substance* was shared by all members; nominalism as postulated by Roscelin (ca 1045-1120), whereby members cannot be referred to by universal categorization via language; and conceptualism as postulated by Peter Abelard (1079-1142), whereby mental conceptions can distinguish the difference between universals (abstractions) and particulars (individuals). Each perspective offered a unique interpretation of epistemology that would be utilized, to varying degrees, by philosophers of the Enlightenment. Nevertheless, theological implications compounded matters further because ontology and teleology served to skew perceptions, as depicted in Part I, subsection 1.1.0-1.1.1; 1.3-1.30. Although William Ockham (ca 1285-1349), a nominalist, offered the following pragmatic perspective *"Pluralitas non est poneneda sine necessitate"* or entities should a multiplied unnecessarily (Stumpf 1994; Flew 1971), the implications for scientific universals may not always be readily apparent. Without proper causal explanation, a premature Ockham's reduction can lead to an erroneous elimination and justification.

6.1.1 In proceeding with this inquiry, the author defines universals *as being summation or an assessed concomitant variation, via memory, of cognitively complex relationships among particular attributes within perception of the external world.* Similar to conceptualism, multiple categorizations, via experiences, allow for dynamic representations and identifications (Dennett 1995; 1991; Pinker 1997). Taxonomy

serves to express these universals in terms of distinct taxonomical units. As stated in Part II, subsection 2.2-2.2.0, particular traits can be misleading and often result in either misclassification or epistemological obfuscation (Falk 1988; Skelton 1998; Tobias 1988). Such is the nature that gives rise in a disagreement of attitude, whereas primacy of traits becomes an issue. However, there must be a clear distinction between *principle(s)* of universals and remaining particulars. According to the author, the principle(s) of universals is defined *as being comprised of particulars which are critical to the formation and cohesion of the whole (universal).* The inter-relationships among particulars are not always of significance. Yet, the combination of significant particulars is representative of the governing universal. It is from these universals that causal justification can lead to proper taxonomical classification. Should universals not exist as stated by the author, the phenomenological reality surrounding epistemology would negate any scientific inquiry.

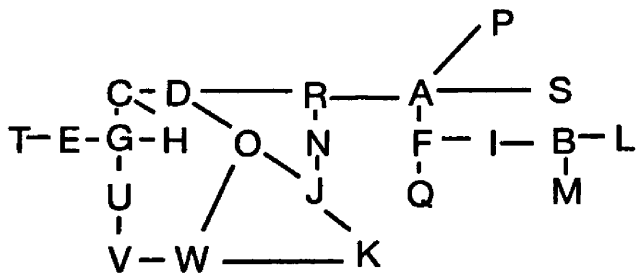
1.6.2 Though defending the existence of universals may appear to be moot and irrelevant, the significance of universals and relationships among particulars become important in taxonomical assessment. In addressing methodological and specimen concerns, the existence of universals, as depicted herein, solidifies the parsimony concerning principle(s) of said universals. The resulting multiple phenomena among the principle(s) promote causal connections with contiguous particulars within universal(s) as substantiated by statistical analysis. Thus, the application of the Bipedal Index and Cranial Capacity/Bipedality Efficiency Index is justified. As for the individual specimens, as stated in Part III, subsection 3.1, some specimens have questionable morphological integrity. Despite this problem, the application of the universal has produced justifiable taxonomical placement with a degree of probability. Even acknowledging the condition of specimens, the application of the Bipedal Index and Cranial Capacity/Bipedality Efficiency Index

is justified. Any augmented differences in attitude based on interpretation are grounded in the degree of projected probabilities.

Princeps Nitor: Correlative Logic

6.2 As depicted in the aforementioned issue concerning universals, the cognitive factors utilized in object recognition and evaluations have critical importance. Accuracy and validity depend upon successfully reflecting this phenomenological reality. Through the recognition of an object, the specimen *A. afarensis,* for example, cannot indicate genealogy or which traits are parsimoniously derived, whereas the constituted principles give clues to both form and function. In this manner, the universal depicted by the Hominidae Theorem in Table 8, Part IV, subsection 4.1.3, illustrates this process. Such justification is illustrated in Figure 11.

Figure 11 - Correlative Schematic



(X)

Whereas:

A= Body weight; B= Brain weight; C= Foramen magnum length; D= Foramen magnum breadth; E= Mandibular fossa to Basion; F= Opisthion to Opisthocranion; G= Occipital condyle length; H= Occipital condyle breadth; I = Cranial capacity; J= Foramen magnum area; K= BPI; L= BPII; M= Bpi; N= Depth of mandibular fossa; O= External cranial base flexation; P= Inclination of the foramen magnum; Q= Inclination of the nuchal line; R= Foramen magnum

to Bi-tympanic line; S= Cranial capacity/Bipedality efficiency index; T= Mandibular fossa to Basion/Bipedality index; U= Hormion to Basion; V= Nasal breadth; and W= Nasal height; X= unknown variable. Furthermore:

J, K, L, M, and S can never be intermediate but terminally universal; E, J, and B are determinate (principles of universals); and F and R are transitionally cohesive and terminal (see Table 14). Set by the postulation in Part II, subsection 2.3, the universals of J, K, L, M, and S indicate the relationship among principle and remaining particulars. Though J is pivotal, whereby linking the principles to the universal, the transitional particular of F and R provide the developmental cohesion among components as depicted in Table 12 of Part IV, subsection 4.3.0. This proceeds from the interrelationship which becomes stipulated.

6.2.0 It is stipulated that C~D and G~H is core features that limit both E (R) and F, as reflected by N; whereas O and U would constitute factors underlying T (effecting V and W). From the transitory R, N has an affinity with F, and then translated into I – which encases B. The universals of J, K, L, M, and S illustrate the truth of this relationship via B, E, and the pivotal J. If B, E, and J were not determinate (principles), as seen in Table 14, then F and R would not be inclusive and the universals would cease; thus, rendering morphological features unintelligible. This is certainly not the case since J reflects the correlation among C, D, G, H, B, O, N, and R; besides the K and L. Disregarding C~D and G~H, whereby the inclusive perimeter ensures this correlation, and should any correlative variable of B, O, N, and R not be true, then the relationship among J, K, M, L, S, and P would fail to provide the sensitivity regarding the inter-correlations of C~D and G~H and the intra-correlations with remaining particulars (variables). Obviously this is not the case since variation in C~D and G~H would have a "domino effect" or a chain reaction among the other particulars. As to the existence of X, X is a phenomenological reality. The degree

by which X correlates with other particulars are unknown; yet, it can be assured that the governing principles established herein, via development, would remain unaffected. The necessity of existence and causality, as seen in Part II, would validate this conclusion and the *Princeps Nitor* in its entirety.

Table 14 Correlative Logic Table

	Comp I (J)	Comp II (B)	Comp III (E)
F		**.558**	**.699**
H		.583	
I		.934	
K	.885		
L		.837	
S		.655	
N			.702
Q			.842
C	.900		
D	.915		
O	.872		
R	**.619**		**.510**

6.2.1 When performing an analysis on the correlative logic, the validity of the Hominidae Theorem depends upon the degree of correlation among particulars. Figure 11, based on correlations found in Appendixes A and B, illustrate this contingency. The degree of correlation among variables is reflected within the relative placement of particulars with each other. For example, A (body weight) may have a high correlation with F (Opisthion to Opisthocranion) where r = .627 @ .096 but correlations with other particulars decrease in value as distance occurs, e.g., O (External Cranial Base Flexation) r = -.174 @ .680. Though genealogical causality cannot be directly ascertained, relationship among particulars can be established. Once again, embryology becomes essential in establishing hierarchical relationships, e.g., sequences of morphological existence (Table 14). Changes in the core components C~D will have an affect on the

remaining radiated particulars. This is evident during human maturation. Any gross mutations, as seen in genetic anomalies, would have adverse affects on functionality and reduce fitness. This would result in possible individual extinction and would signify a shift in evolutionary trends. Considering relationships as depicted in Figure 11, in conjunction with homeostasis, the probably of a "Cambrian Explosion" resulting from the proposed Punctuated Equilibrium seems to be highly improbable. Darwinian gradualism appears to be a more accurate depiction, whereby variation resulting in speciation and parallel evolution becomes more of a probable explanation of current evidence. In an overall evaluation, the depictions contained herein are both significant and testable; thus, the theorem and the subsequent application are justified.

Finale

6.3 Throughout this scientific inquiry, the author has attempted to illustrate the philosophical implications surrounding taxonomical structuring. These implications may seem unimportant when applied to non-human specimens. However, when applied to the human species, personal (species) egoism results in an anthropomorphic elevation of traits into taxonomical obscurity. Although anthropocentric attitudes may be reduced, epistemological problems remain. As Darwin stated, the genealogical relationship must be central to this evaluation. This statement withstanding, Darwin never gave set criteria of traits that should be utilized. In this manner, the author sought to find those expressions that would give clues to genealogical descent. Thus, embryology was utilized. When assessing the various possibilities, an understanding between form and function within a dynamic framework becomes necessary to determine critical traits. In order to reduce epistemological problems, the author's inquiry proceeded by the following suppositions: (1) embryonic development provides the basic foundational form/function of known attributes; (2) each variable is held

complete and separate from other variables; (3) correlative relationships are imposed on variables to provide structural relationships; and (4) the organism's morphological functionality must agree with the known correlative relationships. By eliminating both causality and traits influenced by environmental factors, the remaining traits (variables) allow for a proper evaluation of inter/intra-variable relationships. However, these relationships are not always evident. This is exemplified by factors involved with the Hominidae theorem.

6.3.0 The importance of the relationship between parts to the whole is more evident in the Hominidae theorem than any particular juncture in the long history of taxonomy. Accepting the conditional research provisions indicated by Skelton et al (1986), the author attempted to define new variables that would indicate a universal criteria by which taxonomy could be preformed. Invoking Hume to the postulated cranial characteristic, the resulting view on causality would ensure an unbiased assessment of morphological characteristics. The relationship among variable expressions resulted in the discovery of the Hominidae Theorem. The significance of the theorem and its subsequent application is justified. Yet it should be noted that the determining factors in evaluation, though justified, result in the postulated phylogeny which posses a lesser degree of certainty due to the nature of causality within the fossil record. Nevertheless, greater clarity of dynamic relationships is depicted within this inquiry. The importance of BPI, BPII, and the FMA is that it can reflect minute changes that would result in the projected degree of bipedality, cranial capacity, and prognathism (see Figure 11). Changes reflected in these variables will also be indicators of modifications expressed in the post-cranial skeleton. When applied to individual specimens, it is postulated that a greater continuity or gradual trend toward the modern form of our species will be illustrated. Previously misclassified specimens and an incomplete fossil record can never bring about the degree of certainty that is expressed by the theorem implemented by the author; yet reclassification of

known or future species would probably result in the creation of new taxons or taxonomical reassignments, as in the case of *A. (H) habilis*, uncovering the possibility of multiple speciation and variation.

6.3.1 In the process of providing an independent and unbiased definition of *Homo*, the author attempted to remove any epistemological and anthropocentric barriers that would inhibit proper species designation by providing a possible method of standardization in the taxonomical determination. In its entirety, this inquiry validates the existence of universals and an appropriate means by which to differentiate among species. As to the methodology and validity of the postulated phylogeny by Skelton et al. (1986), the determining methodology and the resulting outcome are valid; however, it does not provide a critical degree of discriminatory power. This is reflected in the differences between the author's postulated cladogram and phylogeny and Skelton et al. (1986). The author contends that this inquiry is a refinement of the methodological process as postulated by Skelton el al. (1986), not a negation of it. The theoretical contributions made by Skelton, McHenry, and Drawnhorn (1986) are both significant and profound, for their contributions have directed this inquiry to its surprising conclusion. This independent verification of their methodology has several philosophical implications as depicted in this scientific inquiry: (1) providing a means by which taxonomical differentiation between speciation and variation can be made; (2) identifying critical and pivotal morphological characteristics; (3) acknowledging the factors surrounding the progression of definitive characteristics pertaining to the rise of humanity; and (4) advocating a naturalistic view of our species within an evolutionary framework. Stemming from this research, it is speculated that additional inquiries into the evolution of primate anatomy may be fruitful in the understanding of the modern form/function of our species; specifically in appreciating the relationship between the areas of endocranial casts and post-cranial extremities of our remote

ancestors. As future advancements and discoveries are procured, the author expects and hopes for progressive refinements to the postulates contained within this inquiry. Such is the nature of science for an evolving species.

Appendixes

Appendix A. Correlations

		Body Weight (g)	Brain Weight (mg)	Foramen Magnum Length (mm)	Foramen Magnum Breadth (mm)
Body Weight (g)	Pearson Correlation	1	.170	-.131	-.085
	Sig. (2-tailed)	.	.687	.758	.841
	N	8	8	8	8
Brain Weight (mg)	Pearson Correlation	.170	1	.553	.570
	Sig. (2-tailed)	.687	.	.155	.140
	N	8	8	8	8
Foramen Magnum Length (mm)	Pearson Correlation	-.131	.553	1	.945(**)
	Sig. (2-tailed)	.758	.155	.	.000
	N	8	8	8	8
Foramen Magnum Breadth (mm)	Pearson Correlation	-.085	.570	.945(**)	1
	Sig. (2-tailed)	.841	.140	.000	.
	N	8	8	8	8
Mandibular Fossa/ Basion (mm)	Pearson Correlation	-.314	-.077	-.168	-.376
	Sig. (2-tailed)	.449	.857	.691	.359
	N	8	8	8	8
Opisthion/ Opisthocranion (mm)	Pearson Correlation	.627	.659	.236	.330
	Sig. (2-tailed)	.096	.076	.574	.425
	N	8	8	8	8
Hormion/ Basion (mm)	Pearson Correlation	-.210	-.207	-.141	-.087
	Sig. (2-tailed)	.617	.622	.739	.837
	N	8	8	8	8

Nazal Breadth (mm)	Pearson Correlation	.120	.106	.134	.344
	Sig. (2-tailed)	.777	.803	.751	.403
	N	8	8	8	8
Nazal Height (mm)	Pearson Correlation	-.412	.381	.418	.570
	Sig. (2-tailed)	.310	.351	.302	.140
	N	8	8	8	8
Occipital Condyle Length (mm)	Pearson Correlation	-.244	.195	.600	.436
	Sig. (2-tailed)	.561	.644	.116	.281
	N	8	8	8	8
Occipital Condyle Breadth (mm)	Pearson Correlation	-.550	.549	.593	.533
	Sig. (2-tailed)	.158	.159	.121	.173
	N	8	8	8	8
Cranial Capacity (cm3)	Pearson Correlation	-.023	.966(**)	.577	.536
	Sig. (2-tailed)	.957	.000	.135	.171
	N	8	8	8	8
Cranial Capacity/ Bipedality Efficiency Index	Pearson Correlation	.534	.712(*)	-.136	-.049
	Sig. (2-tailed)	.173	.048	.749	.909
	N	8	8	8	8
Saggital Crest	Pearson Correlation	.018	.581	.078	.203
	Sig. (2-tailed)	.966	.131	.854	.629
	N	8	8	8	8
External Cranial Base Flexation	Pearson Correlation	-.174	.428	.706	.845(**)
	Sig. (2-tailed)	.680	.290	.050	.008
	N	8	8	8	8
Depth of Mandibular Fossa	Pearson Correlation	-.070	.491	.683	.707
	Sig. (2-tailed)	.869	.217	.062	.050
	N	8	8	8	8

Foramen Magnum/bi-tympanic	Pearson Correlation	.142	-.093	.596	.570
	Sig. (2-tailed)	.737	.827	.119	.141
	N	8	8	8	8
Inclination of Foramen Magnum	Pearson Correlation	.767(*)	.467	.323	.360
	Sig. (2-tailed)	.026	.243	.435	.381
	N	8	8	8	8
Inclination of Nuchal Plane	Pearson Correlation	.439	.433	.380	.439
	Sig. (2-tailed)	.277	.284	.353	.277
	N	8	8	8	8
O-M Sinus in Hight Frq	Pearson Correlation	.207	-.219	.308	.098
	Sig. (2-tailed)	.622	.602	.458	.817
	N	8	8	8	8

		Mandibular Fossa/Basion (mm)	Opisthion/ Opisthocranion (mm)	Hormion/ Basion (mm)	Nazal Breadth (mm)
Body Weight (g)	Pearson Correlation	-.314	.627	-.210	.120
	Sig. (2-tailed)	.449	.096	.617	.777
	N	8	8	8	8
Brain Weight (mg)	Pearson Correlation	-.077	.659	-.207	.106
	Sig. (2-tailed)	.857	.076	.622	.803
	N	8	8	8	8
Foramen Magnum Length (mm)	Pearson Correlation	-.168	.236	-.141	.134
	Sig. (2-tailed)	.691	.574	.739	.751
	N	8	8	8	8
Foramen Magnum Breadth (mm)	Pearson Correlation	-.376	.330	-.087	.344
	Sig. (2-tailed)	.359	.425	.837	.403
	N	8	8	8	8
Mandibular Fossa/ Basion (mm)	Pearson Correlation	1	-.597	.492	-.066
	Sig. (2-tailed)	.	.118	.216	.877
	N	8	8	8	8

Opisthion/ Opisthocranion (mm)	Pearson Correlation	-.597	1	-.396	-.020
	Sig. (2-tailed)	.118	.	.332	.963
	N	8	8	8	8
Hormion/ Basion (mm)	Pearson Correlation	.492	-.396	1	.662
	Sig. (2-tailed)	.216	.332	.	.074
	N	8	8	8	8
Nasal Breadth (mm)	Pearson Correlation	-.066	-.020	.662	1
	Sig. (2-tailed)	.877	.963	.074	.
	N	8	8	8	8
Nasal Height (mm)	Pearson Correlation	-.031	-.011	.451	.528
	Sig. (2-tailed)	.942	.979	.262	.179
	N	8	8	8	8
Occipital Condyle Length (mm)	Pearson Correlation	.545	-.219	.532	.224
	Sig. (2-tailed)	.162	.603	.175	.594
	N	8	8	8	8
Occipital Condyle Breadth (mm)	Pearson Correlation	.476	-.163	.405	.285
	Sig. (2-tailed)	.233	.699	.320	.493
	N	8	8	8	8
Cranial Capacity (cm3)	Pearson Correlation	.029	.552	-.248	-.072
	Sig. (2-tailed)	.946	.156	.553	.866
	N	8	8	8	8
Saggital Crest	Pearson Correlation	.286	.082	.439	.642
	Sig. (2-tailed)	.493	.847	.276	.086
	N	8	8	8	8
External Cranial Base Flexation	Pearson Correlation	-.326	.060	-.021	.540
	Sig. (2-tailed)	.430	.888	.960	.167
	N	8	8	8	8

Depth of Mandibular Fossa	Pearson Correlation	-.543	.610	-.296	-.156
	Sig. (2-tailed)	.164	.109	.476	.711
	N	8	8	8	8
Foramen Magnum/bi-tympanic	Pearson Correlation	-.608	.248	-.416	-.150
	Sig. (2-tailed)	.109	.554	.306	.723
	N	8	8	8	8
Inclination of Foramen Magnum	Pearson Correlation	-.401	.582	-.508	.092
	Sig. (2-tailed)	.325	.130	.199	.829
	N	8	8	8	8
Inclination of Nuchal Plane	Pearson Correlation	-.782(*)	.877(**)	-.603	-.231
	Sig. (2-tailed)	.022	.004	.113	.583
	N	8	8	8	8
O-M Sinus in Hight Frq	Pearson Correlation	.139	.021	.056	-.263
	Sig. (2-tailed)	.742	.960	.894	.530
	N	8	8	8	8

		Occipital Condyle Length (mm)	Occipital Condyle Breadth (mm)	Cranial Capacity (cm3)
Body Weight (g)	Pearson Correlation	-.244	-.550	-.023
	Sig. (2-tailed)	.561	.158	.957
	N	8	8	8
Brain Weight (mg)	Pearson Correlation	.195	.549	.966(**)
	Sig. (2-tailed)	.644	.159	.000
	N	8	8	8
Foramen Magnum Length (mm)	Pearson Correlation	.600	.593	.577
	Sig. (2-tailed)	.116	.121	.135
	N	8	8	8
Foramen Magnum Breadth (mm)	Pearson Correlation	.436	.533	.536
	Sig. (2-tailed)	.281	.173	.171
	N	8	8	8

Mandibular Fossa/ Basion (mm)	Pearson Correlation	.545	.476	.029
	Sig. (2-tailed)	.162	.233	.946
	N	8	8	8
Opisthion/ Opisthocranion (mm)	Pearson Correlation	-.219	-.163	.552
	Sig. (2-tailed)	.603	.699	.156
	N	8	8	8
Hormion/ Basion (mm)	Pearson Correlation	.532	.405	-.248
	Sig. (2-tailed)	.175	.320	.553
	N	8	8	8
Nasal Breadth (mm)	Pearson Correlation	.224	.285	-.072
	Sig. (2-tailed)	.594	.493	.866
	N	8	8	8
Nasal Height (mm)	Pearson Correlation	.324	.675	.351
	Sig. (2-tailed)	.434	.066	.394
	N	8	8	8
Occipital Condyle Length (mm)	Pearson Correlation	1	.724(*)	.261
	Sig. (2-tailed)	.	.042	.533
	N	8	8	8
Occipital Condyle Breadth (mm)	Pearson Correlation	.724(*)	1	.632
	Sig. (2-tailed)	.042	.	.093
	N	8	8	8
Cranial Capacity (cm3)	Pearson Correlation	.261	.632	1
	Sig. (2-tailed)	.533	.093	.
	N	8	8	8
Saggital Crest	Pearson Correlation	.161	.579	.472
	Sig. (2-tailed)	.704	.132	.237
	N	8	8	8
External Cranial Base Flexation	Pearson Correlation	.178	.481	.350
	Sig. (2-tailed)	.673	.227	.395
	N	8	8	8
Depth of Mandibular Fossa	Pearson Correlation	.202	.241	.534
	Sig. (2-tailed)	.632	.565	.173
	N	8	8	8

Foramen Magnum/bi-tympanic	Pearson Correlation	.124	-.228	-.091
	Sig. (2-tailed)	.769	.588	.830
	N	8	8	8
Inclination of Foramen Magnum	Pearson Correlation	-.189	-.241	.303
	Sig. (2-tailed)	.655	.565	.466
	N	8	8	8
Inclination of Nuchal Plane	Pearson Correlation	-.235	-.276	.389
	Sig. (2-tailed)	.575	.509	.341
	N	8	8	8
O-M Sinus in Hight Frq	Pearson Correlation	.583	-.083	-.161
	Sig. (2-tailed)	.129	.844	.703
	N	8	8	8

		Saggital Crest	External Cranial Base Flexation	Depth of Mandibular Fossa	Foramen Magnum/bi-tympanic
Body Weight (g)	Pearson Correlation	.018	-.174	-.070	.142
	Sig. (2-tailed)	.966	.680	.869	.737
	N	8	8	8	8
Brain Weight (mg)	Pearson Correlation	.581	.428	.491	-.093
	Sig. (2-tailed)	.131	.290	.217	.827
	N	8	8	8	8
Foramen Magnum Length (mm)	Pearson Correlation	.078	.706	.683	.596
	Sig. (2-tailed)	.854	.050	.062	.119
	N	8	8	8	8
Foramen Magnum Breadth (mm)	Pearson Correlation	.203	.845(**)	.707	.570
	Sig. (2-tailed)	.629	.008	.050	.141
	N	8	8	8	8
Mandibular Fossa/ Basion (mm)	Pearson Correlation	.286	-.326	-.543	-.608
	Sig. (2-tailed)	.493	.430	.164	.109
	N	8	8	8	8

Opisthion/ Opisthocranion (mm)	Pearson Correlation	.082	.060	.610	.248
	Sig. (2-tailed)	.847	.888	.109	.554
	N	8	8	8	8
Hormion/ Basion (mm)	Pearson Correlation	.439	-.021	-.296	-.416
	Sig. (2-tailed)	.276	.960	.476	.306
	N	8	8	8	8
Nasal Breadth (mm)	Pearson Correlation	.642	.540	-.156	-.150
	Sig. (2-tailed)	.086	.167	.711	.723
	N	8	8	8	8
Nasal Height (mm)	Pearson Correlation	.617	.669	.355	-.130
	Sig. (2-tailed)	.103	.070	.387	.759
	N	8	8	8	8
Occipital Condyle Length (mm)	Pearson Correlation	.161	.178	.202	.124
	Sig. (2-tailed)	.704	.673	.632	.769
	N	8	8	8	8
Occipital Condyle Breadth (mm)	Pearson Correlation	.579	.481	.241	-.228
	Sig. (2-tailed)	.132	.227	.565	.588
	N	8	8	8	8
Cranial Capacity (cm3)	Pearson Correlation	.472	.350	.534	-.091
	Sig. (2-tailed)	.237	.395	.173	.830
	N	8	8	8	8
Saggital Crest	Pearson Correlation	1	.447	-.203	-.645
	Sig. (2-tailed)	.	.267	.629	.084
	N	8	8	8	8
External Cranial Base Flexation	Pearson Correlation	.447	1	.325	.289
	Sig. (2-tailed)	.267	.	.432	.488
	N	8	8	8	8

Depth of Mandibular Fossa	Pearson Correlation	-.203	.325	1	.619
	Sig. (2-tailed)	.629	.432	.	.102
	N	8	8	8	8
Foramen Magnum/bi-tympanic	Pearson Correlation	-.645	.289	.619	1
	Sig. (2-tailed)	.084	.488	.102	.
	N	8	8	8	8
Inclination of Foramen Magnum	Pearson Correlation	.162	.361	.117	.313
	Sig. (2-tailed)	.702	.379	.782	.451
	N	8	8	8	8
Inclination of Nuchal Plane	Pearson Correlation	-.325	.104	.788(*)	.629
	Sig. (2-tailed)	.433	.807	.020	.095
	N	8	8	8	8
O-M Sinus in Hight Frq	Pearson Correlation	-.596	-.333	.260	.577
	Sig. (2-tailed)	.119	.420	.534	.134
	N	8	8	8	8

		Inclination of Foramen Magnum	Inclination of Nuchal Plane	O-M Sinus in Hight Frq
Body Weight (g)	Pearson Correlation	.767(*)	.439	.207
	Sig. (2-tailed)	.026	.277	.622
	N	8	8	8
Brain Weight (mg)	Pearson Correlation	.467	.433	-.219
	Sig. (2-tailed)	.243	.284	.602
	N	8	8	8
Foramen Magnum Length (mm)	Pearson Correlation	.323	.380	.308
	Sig. (2-tailed)	.435	.353	.458
	N	8	8	8

Foramen Magnum Breadth (mm)	Pearson Correlation	.360	.439	.098
	Sig. (2-tailed)	.381	.277	.817
	N	8	8	8
Mandibular Fossa/Basion (mm)	Pearson Correlation	-.401	-.782(*)	.139
	Sig. (2-tailed)	.325	.022	.742
	N	8	8	8
Opisthion/ Opisthocranion (mm)	Pearson Correlation	.582	.877(**)	.021
	Sig. (2-tailed)	.130	.004	.960
	N	8	8	8
Hormion/ Basion (mm)	Pearson Correlation	-.508	-.603	.056
	Sig. (2-tailed)	.199	.113	.894
	N	8	8	8
Nasal Breadth (mm)	Pearson Correlation	.092	-.231	-.263
	Sig. (2-tailed)	.829	.583	.530
	N	8	8	8
Nasal Height (mm)	Pearson Correlation	-.153	-.115	-.375
	Sig. (2-tailed)	.717	.786	.360
	N	8	8	8
Occipital Condyle Length (mm)	Pearson Correlation	-.189	-.235	.583
	Sig. (2-tailed)	.655	.575	.129
	N	8	8	8
Occipital Condyle Breadth (mm)	Pearson Correlation	-.241	-.276	-.083
	Sig. (2-tailed)	.565	.509	.844
	N	8	8	8
Cranial Capacity (cm3)	Pearson Correlation	.303	.389	-.161
	Sig. (2-tailed)	.466	.341	.703
	N	8	8	8

Saggital Crest	Pearson Correlation	.162	-.325	-.596
	Sig. (2-tailed)	.702	.433	.119
	N	8	8	8
External Cranial Base Flexation	Pearson Correlation	.361	.104	-.333
	Sig. (2-tailed)	.379	.807	.420
	N	8	8	8
Depth of Mandibular Fossa	Pearson Correlation	.117	.788(*)	.260
	Sig. (2-tailed)	.782	.020	.534
	N	8	8	8
Foramen Magnum/bi-tympanic	Pearson Correlation	.313	.629	.577
	Sig. (2-tailed)	.451	.095	.134
	N	8	8	8
Inclination of Foramen Magnum	Pearson Correlation	1	.487	.000
	Sig. (2-tailed)	.	.221	1.000
	N	8	8	8
Inclination of Nuchal Plane	Pearson Correlation	.487	1	.207
	Sig. (2-tailed)	.221	.	.622
	N	8	8	8
O-M Sinus in Hight Frq	Pearson Correlation	.000	.207	1
	Sig. (2-tailed)	1.000	.622	.
	N	8	8	8

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Appendix B Bpi and CC/BPI Correlations

		Foramen Magnum Area (mm)	Biped sub1 Area (mm)	Biped sub2 Area (mm)	Bipedal Index	Cranial Capacity/Bipedality Efficiency Index
Body Weight (g)	Pearson Correlation	-.114	-.005	.216	-.171	.534
	Sig. (2-tailed)	.789	.990	.607	.686	.173
	N	8	8	8	8	8
Brain Weight (mg)	Pearson Correlation	.576	.204	.759(*)	.659	.712(*)
	Sig. (2-tailed)	.135	.629	.029	.075	.048
	N	8	8	8	8	8
Foramen Magnum Length (mm)	Pearson Correlation	.985(**)	.746(*)	.614	.377	-.136
	Sig. (2-tailed)	.000	.034	.106	.357	.749
	N	8	8	8	8	8
Foramen Magnum Breadth (mm)	Pearson Correlation	.986(**)	.855(**)	.521	.446	-.049
	Sig. (2-tailed)	.000	.007	.186	.268	.909
	N	8	8	8	8	8
Mandibular Fossa/Basion (mm)	Pearson Correlation	-.287	-.316	.061	-.282	-.105
	Sig. (2-tailed)	.491	.445	.886	.499	.805
	N	8	8	8	8	8
Opisthion/Opisthocranion (mm)	Pearson Correlation	.303	.065	.622	.285	.674
	Sig. (2-tailed)	.465	.878	.100	.493	.067
	N	8	8	8	8	8

Hormion/Basion (mm)	Pearson Correlation	-.122	.250	.026	-.572	-.248
	Sig. (2-tailed)	.774	.551	.951	.139	.553
	N	8	8	8	8	8
Nasal Breadth (mm)	Pearson Correlation	.231	.657	.000	-.093	.060
	Sig. (2-tailed)	.582	.077	1.000	.826	.888
	N	8	8	8	8	8
Nasal Height (mm)	Pearson Correlation	.501	.585	.204	.313	.027
	Sig. (2-tailed)	.206	.128	.628	.451	.950
	N	8	8	8	8	8
Occipital Condyle Length (mm)	Pearson Correlation	.520	.459	.588	-.299	-.357
	Sig. (2-tailed)	.186	.253	.125	.472	.386
	N	8	8	8	8	8
Occipital Condyle Breadth (mm)	Pearson Correlation	.570	.378	.506	.308	-.010
	Sig. (2-tailed)	.140	.356	.201	.458	.982
	N	8	8	8	8	8
Cranial Capacity (cm3)	Pearson Correlation	.574	.101	.771(*)	.670	.596
	Sig. (2-tailed)	.137	.811	.025	.069	.119
	N	8	8	8	8	8
Foramen Magnum Area (mm)	Pearson Correlation	1	.802(*)	.587	.418	-.090
	Sig. (2-tailed)	.	.017	.126	.302	.833
	N	8	8	8	8	8
Biped sub1 Area (mm)	Pearson Correlation	.802(*)	1	.229	.098	-.268
	Sig. (2-tailed)	.017	.	.585	.817	.521
	N	8	8	8	8	8
Biped sub2 Area (mm)	Pearson Correlation	.587	.229	1	.088	.342
	Sig. (2-tailed)	.126	.585	.	.835	.408
	N	8	8	8	8	8

Bipedal Index	Pearson Correlation	.418	.098	.088	1	.486
	Sig. (2-tailed)	.302	.817	.835	.	.222
	N	8	8	8	8	8
Cranial Capacity/Bipedality Efficiency Index	Pearson Correlation	-.090	-.268	.342	.486	1
	Sig. (2-tailed)	.833	.521	.408	.222	.
	N	8	8	8	8	8

Saggital Crest	Pearson Correlation	.133	.227	.208	.374	.585
	Sig. (2-tailed)	.753	.589	.621	.361	.128
	N	8	8	8	8	8
External Cranial Base Flexation	Pearson Correlation	.776(*)	.832(*)	.091	.603	.007
	Sig. (2-tailed)	.024	.010	.830	.114	.987
	N	8	8	8	8	8
Depth of Mandibular Fossa	Pearson Correlation	.724(*)	.395	.638	.284	-.003
	Sig. (2-tailed)	.042	.332	.089	.495	.995
	N	8	8	8	8	8
Foramen Magnum/bi-tympanic	Pearson Correlation	.595	.529	.169	-.042	-.457
	Sig. (2-tailed)	.120	.178	.690	.922	.255
	N	8	8	8	8	8
Inclination of Foramen Magnum	Pearson Correlation	.336	.290	.242	.387	.544
	Sig. (2-tailed)	.416	.487	.564	.344	.163
	N	8	8	8	8	8
Inclination of Nuchal Plane	Pearson Correlation	.434	.152	.490	.269	.300
	Sig. (2-tailed)	.283	.719	.218	.519	.470
	N	8	8	8	8	8
O-M Sinus in Hight Frq	Pearson Correlation	.209	.137	.415	-.636	-.480
	Sig. (2-tailed)	.620	.746	.307	.090	.228
	N	8	8	8	8	8

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed).

Characters

1. **Body weight (g):**
   0. under 39999
   1. between 40000 – 49999
   2. 50000 – up

2. **Brain weight (mg):**
   0. 400000-499999
   1. 500000-599999
   2. 600000-699999
   3. 700000-799999
   4. 800000-899999
   5. 900000-999999
   6. 1000000-up

3. **Foramen magnum length (mm):**
   0. 20-29
   1. 30-39

4. **Foramen magnum breadth (mm):**
   0. 20-29
   1. 30-39

5. **Mandiular fossa/Basion (mm):**
   0. 15-up
   1. 10-14
   2. 5-9

6. **Opisthion/Opisthocranion (mm):**
   0. 20-29
   1. 30-39
   2. 40-49
   3. 50-59

7. Occipital condyle length (mm):

0. x>19
1. x<18

8. Occipital condyle breadth (mm):

0. x>10
1. x<9

9. Cranial capacity (cm3):

0. 400-599
1. 600-899
2. x>900

10. Foramen magnum area (mm):

0. x<599
1. 600-699
2. x>700

11. Biped sub 1 area (mm):

0. x>180
1. x<179

12. Biped sub 2 area (mm):

0. x<999
1. x>1000

13. Biped index:

0. x<29
1. x>30

14. Depth of mandibular fossa:

0. shallow (<15%)
1. variable (shallow/intermediate)
2. Intermediate (15-25%)
3. Deep (>25%)

15. External Base Flexation :

0. flat
1. moderate
2. flexed

16. Inclination of Foramen magnum:

0. strongly inclined (posterior)
1. Roughly horizontal
2. Strongly inclined (anterior)

17. Inclination of nuchal plane:

0. steeply inclined
1. intermediate
2. weakly inclined

18. Foramen magnum/bi-tympanic :

0. well posterior
1. at bi-tympanic line
2. variable
3. well anterior

19. Capactiy/Bipedality Efficiency Index:

0. .500 - .700
1. .8 - .999
2. 1.00 – 1.100
3. 1.2 – 1.4
4. 1.5 – 1.7

Appendix D Correlation for Postulated MFB/BPi

		Mandibular Fossa/ Bpi
Body Weight (g)	Pearson Correlation	-.548
	Sig. (2-tailed)	.160
	N	8
Brain Weight (mg)	Pearson Correlation	-.398
	Sig. (2-tailed)	.328
	N	8
Foramen Magnum Length (mm)	Pearson Correlation	-.242
	Sig. (2-tailed)	.563
	N	8
Foramen Magnum Breadth (mm)	Pearson Correlation	-.270
	Sig. (2-tailed)	.517
	N	8
Mandibular Fossa/Basion (mm)	Pearson Correlation	.697
	Sig. (2-tailed)	.055
	N	8
Opisthion/Opisthocranion (mm)	Pearson Correlation	-.897(**)
	Sig. (2-tailed)	.003
	N	8
Hormion/Basion (mm)	Pearson Correlation	.615
	Sig. (2-tailed)	.105
	N	8
Nazal Breadth (mm)	Pearson Correlation	.321
	Sig. (2-tailed)	.439
	N	8

Nazal Height (mm)	Pearson Correlation	.264
	Sig. (2-tailed)	.528
	N	8
Occipital Condyle Length (mm)	Pearson Correlation	.274
	Sig. (2-tailed)	.512
	N	8
Occipital Condyle Breadth (mm)	Pearson Correlation	.374
	Sig. (2-tailed)	.362
	N	8
Cranial Capacity (cm3)	Pearson Correlation	-.354
	Sig. (2-tailed)	.390
	N	8
Foramen Magnum Area (mm)	Pearson Correlation	-.279
	Sig. (2-tailed)	.504
	N	8
Biped sub1 Area (mm)	Pearson Correlation	.014
	Sig. (2-tailed)	.974
	N	8
Biped sub2 Area (mm)	Pearson Correlation	-.496
	Sig. (2-tailed)	.212
	N	8
Bipedal Index	Pearson Correlation	-.176
	Sig. (2-tailed)	.677
	N	8
Cranial Capacity/Bipedality Efficiency Index	Pearson Correlation	-.375
	Sig. (2-tailed)	.360
	N	8

Saggital Crest	Pearson Correlation	.358
	Sig. (2-tailed)	.384
	N	8
External Cranial Base Flexation	Pearson Correlation	.083
	Sig. (2-tailed)	.845
	N	8
Depth of Manibular Fossa	Pearson Correlation	-.687
	Sig. (2-tailed)	.060
	N	8
Foramen Magnum/bi-tympanic	Pearson Correlation	-.541
	Sig. (2-tailed)	.166
	N	8
Inclination of Foramen Magnum	Pearson Correlation	-.501
	Sig. (2-tailed)	.206
	N	8
Inclination of Nuchal Plane	Pearson Correlation	-.977(**)
	Sig. (2-tailed)	.000
	N	8
Mandibular Fossa to Bpi	Pearson Correlation	1
	Sig. (2-tailed)	.
	N	8
O-M Sinus in Hight Frq	Pearson Correlation	-.260
	Sig. (2-tailed)	.533
	N	8

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Appendix E MFB/BPI (Prognathism)

Species	FMBPI
A. afarensis	1.95
A. africanus	1.01
A. robustus	1.30
A. boisei	1.30
A. (H) habilis	1.30
H. egaster/ erectus	1.09
H. sapiens	1.20
Pan	3.62

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